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Study 33

Geology of Carbonatite – Alkalic Rock Complexes in Ontario

Borden Township Carbonatite Complex

District of Sudbury

by R.P. Sage

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Foreword

The Borden Township Carbonatite Complex was examined as part of a project, begun in 1974, to study alkalic rock - carbonatite complexes in Ontario. The report describes the rock types and mineralogy of the Borden Township Carbonatite Complex and outlines the history of the mineral exploration efforts within the complex.

V.G. Milne
Director
Ontario Geological Survey

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CHART (back pocket)

Chart A — Figure 3

CONVERSION FACTORS FOR MEASUREMENTS IN ONTARIO GEOLOGICAL SURVEY PUBLICATIONS.

CONVERSION FROM SI TO IMPERIAL			CONVERSION FROM IMPERIAL TO SI		
SI Unit	*Multiplied by*	*Gives*	*Imperial Unit*	*Multiplied by*	*Gives*
		LENGTH			
1 mm	0.039 37	inches	1 inch	**25.4**	mm
1 cm	0.393 70	inches	1 inch	**2.54**	cm
1 m	3.280 84	feet	1 foot	**0.304 8**	m
1 m	0.049 709 7	chains	1 chain	20.116 8	m
1 km	0.621 371	miles (statute)	1 mile (statute)	**1.609 344**	km
		AREA			
1 cm^2	0.155 0	square inches	1 square inch	**6.451 6**	cm^2
1 m^2	10.763 9	square feet	1 square foot	**0.092 903 04**	m^2
1 km^2	0.386 10	square miles	1 square mile	2.589 988	km^2
1 ha	2.471 054	acres	1 acre	0.404 685 6	ha
		VOLUME			
1 cm^3	0.061 02	cubic inches	1 cubic inch	**16.387 064**	cm^3
1 m^3	35.314 7	cubic feet	1 cubic foot	0.028 316 85	m^3
1 m^3	1.308 0	cubic yards	1 cubic yard	0.764 555	m^3
		CAPACITY			
1 L	1.759 755	pints	1 pint	0.568 261	L
1 L	0.879 877	quarts	1 quart	1.136 522	L
1 L	0.219 969	gallons	1 gallon	**4.546 090**	L
		MASS			
1 g	0.035 273 96	ounces (avdp)	1 ounce (avdp)	28.349 523	g
1 g	0.032 150 75	ounces (troy)	1 ounce (troy)	**31.103 476 8**	g
1 kg	2.204 62	pounds (avdp)	1 pound (avdp)	**0.453 592 37**	kg
1 kg	0.001 102 3	tons (short)	1 ton (short)	**907.184 74**	kg
1 t	1.102 311	tons (short)	1 ton (short)	**0.907 184 74**	t
1 kg	0.000 984 21	tons (long)	1 ton (long)	**1016.046 908 8**	kg
1 t	0.984 206 5	tons (long)	1 ton (long)	**1.016 046 908 8**	t
		CONCENTRATION			
1 g/t	0.029 166 6	ounce (troy)/ ton (short)	1 ounce (troy)/ ton (short)	34.285 714 2	g/t
1 g/t	0.583 333 33	pennyweights/ ton (short)	1 pennyweight/ ton (short)	1.714 285 7	g/t

OTHER USEFUL CONVERSION FACTORS

1 ounce (troy) per ton (short)	20.0	pennyweights per ton (short)
1 pennyweight per ton (short)	0.05	ounces (troy) per ton (short)

Note. Conversion factors which are in bold type are exact. The conversion factors have been taken from or have been derived from factors given in the Metric Practice Guide for the Canadian Mining and Metallurgical Industries, published by the Mining Association of Canada in cooperation with the Coal Association of Canada.

GEOLOGY OF CARBONATITE – ALKALIC ROCK COMPLEXES IN ONTARIO

Borden Township Carbonatite Complex

DISTRICT OF SUDBURY

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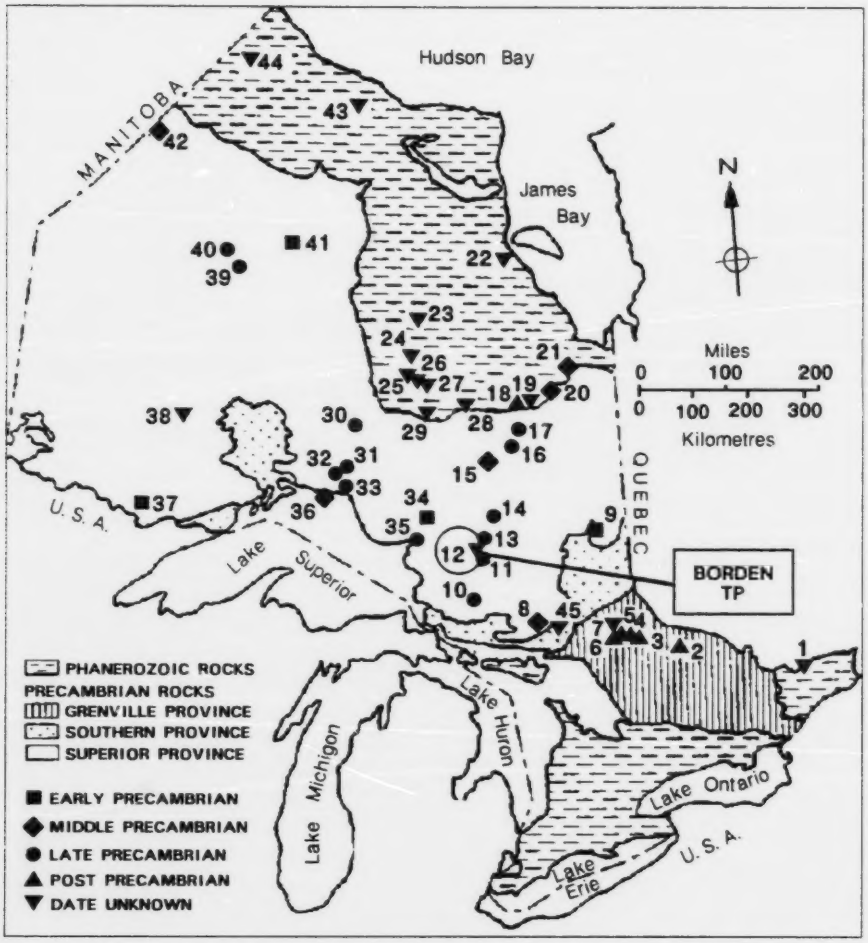

Figure 1. *Key map showing location of carbonatite – alkalic rock complexes in Ontario.*

1. *Eastview*
2. *Brent*
3. *Callander B.*
4. *Manitou Is.*
5. *Burritt Is.*
6. *Iron Is.*
7. *Lavergne*
8. *Spanish R.*
9. *Otto Stock*
10. *Seabrook L.*
11. *Lackner L.*
12. ***Borden Tp.***
13. *Nemegosenda L.*
14. *Shenango Tp.*
15. *Cargill Tp.*
16. *Teetzel Tp.*
17. *Clay-Howells*
18. *Hecla-Kilmer*
19. *Valentine Tp.*
20. *Goldray*
21. *Argor*
22. *Lawashi R.*
23. *Poplar R.*
24. *Albany Forks*
25. *L. Drowning R.*
26. *Kingfisher R. W.*
27. *Kingfisher R. E.,*
28. *Martison L.*
29. *Nagagami R.*
30. *Chipman L. (dikes)*
31. *Killala L.*
32. *Prairie L.*
33. *Port Coldwell*
34. *Herman L.*
35. *Firesand R.*
36. *Slate Is.*
37. *Poohbah L.*
38. *Sturgeon Narrows & Squaw L.*
39. *Schryburt L.*
40. *Big Beaver House*
41. *Wapikopa L.*
42. *"Carb" L.*
43. *Gooseberry Br.*
44. *Niskibi L.*
45. *Nemag L. & Lusk L.*

Silicocarbonatite. A carbonate-rich igneous rock composed of 50 percent or more oxide and silicate minerals. Where the silicate mineralogy exceeds 90 percent, various other rock names are applied, e.g. ijolite, biotitite, pyroxenite.

The definitions of sovite and silicocarbonatite are modified from Heinrich (1966, p.12). The author has found Heinrich's subdivision of the carbonate-rich carbonatitic rocks generally suitable for field use upon modification to a two-fold subdivision at about 50 percent oxide and silicate mineral contents. The two-fold subdivision is more convenient than the four-fold subdivision of Heinrich (1966, p.12) since carbonatites are extremely variable in mineral content over distances of less than a few centimetres. It is difficult to rigorously classify such heterogeneous rocks and the various phases are generally not mappable at any convenient map scale.

General Geology

The Borden Township Carbonatite Complex (Figures 2 and 3) has intruded rocks of the Kapuskasing Subprovince of the Superior Province of the Canadian Shield. This subprovince is characterized by anomalous northeast-trending gravity and isomagnetic contours (Innes 1960). Bennett *et al.* (1967) and Wilson and Brisbin (1965) considered that the Kapuskasing Subprovince represents a horst structure which has brought lower level, upper amphibolite- to granulite-facies rocks into juxtaposition with higher level, lower rank metamorphic rocks. The carbonatite complex has intruded Archean biotite-quartz-plagioclase gneisses which display evidence of fenitization in proximity to the carbonatite intrusion. Examination of drill core indicates that sovite, silicocarbonatite and fenitized wall rock alternate throughout the length of the core. The complex most likely represents a series of sovite and silicocarbonatite cone sheets emplaced into brecciated biotite-quartz-plagioclase gneisses. Table 1 shows lithologic units for the Borden Township Carbonatite Complex.

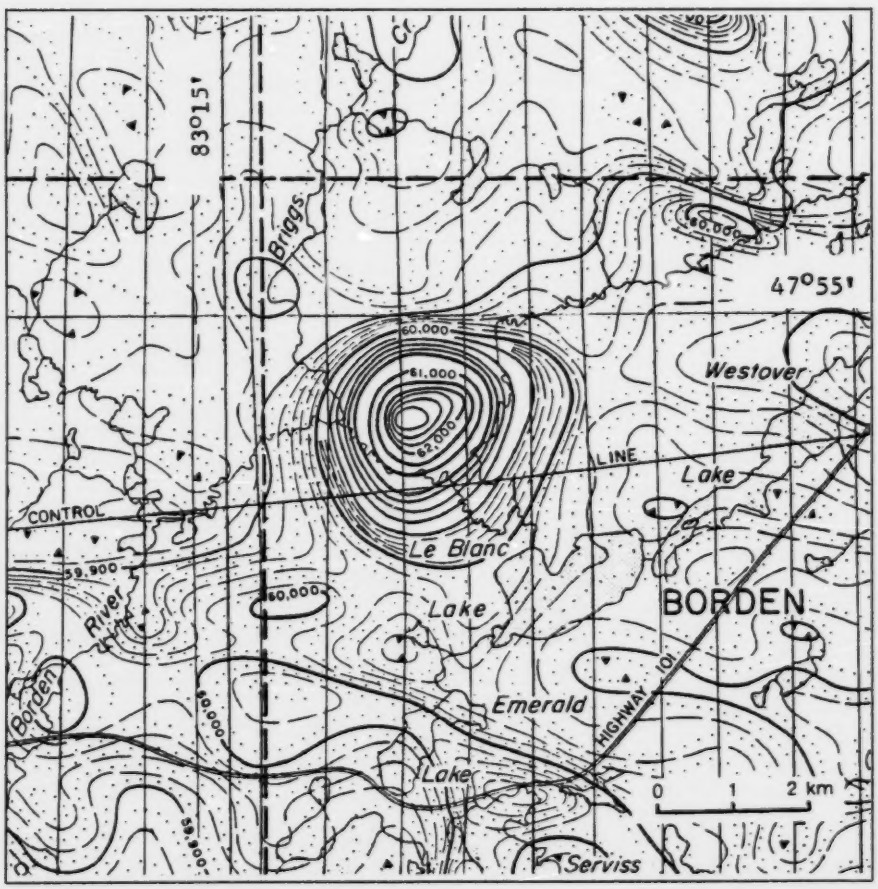

Figure 2. *Aeromagnetic map of the Borden Township Carbonatite Complex (after Map 2232G, ODM-GSC 1963).*

TABLE 1. TABLE OF LITHOLOGIC UNITS FOR THE BORDEN TOWNSHIP CARBONATITE COMPLEX.

CENOZOIC
Recent
Swamp and stream deposits.
Pleistocene
Sand and gravel deposits.

Unconformity

PROTEROZOIC
Borden Township Carbonatite Complex
Dolomite (beforsite) dikes*, lamprophyre dikes.
Sovite and silicocarbonate.
Fenitized biotite-quartz-plagioclase gneiss.

Intrusive Contact

ARCHEAN
Biotite-quartz-plagioclase gneiss.

*Exposed only in A.C.A. Howe International Limited trenches.

ARCHEAN

Biotite-Quartz-Plagioclase Gneiss

Diamond drilling by A.C.A. Howe International Limited encountered numerous intersections of gneissic rocks that have been fenitized to varying degrees, alternating with sovite and silicocarbonatite. In thin section the gneissic rocks are fine grained, massive, equigranular to inequigranular-seriate, granoblastic with straight to serrate grain boundaries. Several sections appear to have a recrystallized porphyroclastic texture. The modal composition varies widely depending on the degree of alteration and several thin sections contain a mineralogy transitional into silicocarbonatite. The mode is estimated to be 15 to 60 percent plagioclase (An_{26-36}), trace to 45 percent biotite, and 0 to 30 percent quartz. The metasomatic minerals formed during the fenitization process include 0 to 25 percent amphibole, 0 to 20 percent clinopyroxene, 0 to 5 percent carbonate; one sample contains approximately 5 percent sericite. An unidentifiable, very fine-grained, turbid alteration occurs in minor amounts in several thin sections. Microcline, sphene and opaques (most likely magnetite) occur in trace to minor amounts.

The plagioclase occurs as anhedral grains, locally turbid, and often displays alteration to sericite. Large grains may be in part porphyroblasts and in part recrystallized porphyroclasts. One specimen with large plagioclase grains displays numerous inclusions within the plagioclase. In this one specimen, the feldspar contains irregular blebs of carbonate and small tabular grains of biotite oriented with their (001) cleavage parallel to the albite twin plane. These larger grains appear porphyroblastic; other grains appear fractured and display rims of fine-grained polygonized feldspar suggesting that they are porphyroclasts recrystallized along their rims. Several specimens display larger grains with both fractured and bent albite twin planes. The grain boundaries between plagioclase-plagioclase and plagioclase-quartz are often recrystallized and appear as a fine-grained granoblastic mosaic. The turbidity of some grains is likely the result of a very fine-grained disseminated alteration which is too fine-grained for optical identification. Very small inclusions of biotite, amphibole, and possibly apatite are present in the larger plagioclase feldspars of one sample.

The biotite occurs as anhedral to subhedral, tabular grains of irregular outline. The mineral generally occurs along grain boundaries or between grains and rarely as inclusions in some of the larger feldspar grains. In the more highly altered

samples the biotite forms an interlocking aggregate of grains. In the samples of high biotite content, a significant portion likely formed by reaction of the carbonatite magma with the gneissic wall rocks during fenitization. The larger biotite grains in these biotite-rich rocks poikilitically enclose plagioclase, carbonate and clinopyroxene and appear porphyroblastic. In one specimen, (001) cleavage of the biotite is bent; in another, quartz along with plagioclase is poikilitically enclosed in biotite.

Quartz occurs as anhedral grains interlocked with each other and plagioclase. The quartz commonly occurs as an aggregate of several grains with good triple junction grain boundaries typical of a well-developed granoblastic texture. Some quartz grains have a weakly developed wavy extinction. In one sample, the quartz grains display numerous subparallel fractures, reminiscent of deformation lamellae. Very tiny, unidentifiable inclusions occur along these fractures. With increasing fenitization the quartz content decreases. The fenite minerals pyroxene, amphibole, and carbonate occur along quartz-plagioclase and plagioclase-plagioclase grain boundaries. The more intense alteration is along quartz-plagioclase grain boundaries. The development of the alteration minerals is often accompanied by polygonization of the quartz-feldspar grain boundaries giving rise to a fine-grained granoblastic texture.

The clinopyroxene is intergranular to feldspar and quartz and varies from anhedral to euhedral in form. The pyroxene is pleochroic from colourless to pale green and is likely aegirine-augite. Pyroxene encloses a grain of biotite in one sample.

The amphibole forms colourless to pale green acicular crystals that vary from anhedral to euhedral. In those samples with a high amphibole content the crystals form a mass of interlocking crystals. The amphibole poikilitically encloses biotite, carbonate and pyroxene. The amphibole appears to have formed later than the pyroxene and may in part have resulted from the breakdown of the pyroxene as the fenitization process proceeded. In one sample, the acicular amphibole crystals are roughly normal to the quartz-feldspar grain boundaries and project into the quartz.

The carbonate occurs in minor quantities and is most common along grain boundaries in close association with amphibole and pyroxene. It also occurs along fractures in mineral grains and as inclusions in some biotite, pyroxene and amphibole grains.

PROTEROZOIC

BORDEN TOWNSHIP CARBONATITE COMPLEX

Silicocarbonatite

Rocks of this group may have several origins: i.e., intrusive dike rocks, cumulative segregations, and extreme fenitization of other rocks. It is impossible to subdivide the silicocarbonatite into these groups since all gradations are possible. The rocks high in biotite may be a product of extreme fenitization while those rich in magnetite, olivine, apatite, amphibole and biotite-phlogopite may represent cumulative phases. Possible dike rocks could be confused with biotite-rich silicocarbonatites formed by reaction of the carbonatite magma with gneissic wall rocks. The samples thought to be representative of dikes display a microporphyritic inequigranular texture.

In thin section silicocarbonatite is fine grained, equigranular, massive, hypidiomorphic with straight to curved grain boundaries. Magnetite-rich samples tend to be medium grained. The mode is estimated to be 10 to 50 percent carbonate, 5 to 70 percent biotite-phlogopite, 0 to 15 percent apatite, 0 to 60 percent amphibole, 0 to 30 percent olivine, and 0 to 35 percent opaques. The opaques are probably magnetite.

The carbonate forms an interlocking mosaic of anhedral grains. In samples of lower carbonate content, the carbonate is interstitial.

The biotite-phlogopite forms anhedral to euhedral grains, generally tabular and irregular in outline. A few grains have ragged edges. Rarely, the (001) cleavage planes are bent. Commonly, the larger grains have pleochroic, colourless to light yellow-brown cores and colourless to dark red-brown rims. This concentric pleochroic zonation suggests that some grains are compositionally zoned from a core of phlogopite composition to a rim of biotite composition. Carbonate, apatite, and opaques have all been observed as small inclusions in the biotite-phlogopite.

The apatite forms anhedral to subhedral, round to round-elongate grains. The apatite forms disseminated grains and local concentrations define crude bands.

Amphibole forms anhedral to euhedral, acicular, colourless crystals. The amphibole is commonly colourless, but may also be pleochroic in pale green. In one specimen, the pleochroic pale green amphibole appears to mantle and replace the colourless amphibole. Some amphibole appears skeletal and encloses carbonate. One specimen of crudely skeletal amphibole encloses small tabular biotite grains oriented such that the (001) cleavage of biotite is parallel to the long axis of the amphibole grain. In olivine-bearing samples the acicular amphibole crystals completely penetrate the olivine grain. In one specimen relict pyroxene is enclosed within the amphibole grains. Amphiboles of two compositions are likely present. The colourless amphibole appears more euhedral and acicular and seems to occur preferentially in the more carbonate-rich end-members of the silicocarbonatites.

The olivine occurs as round anhedral grains which locally are segregated into crude bands. The more olivine-rich samples appear to be also more magnetite-rich. Rarely the larger olivine grains are somewhat skeletal along the edges of the grains and may enclose irregular blebs of carbonate. Acicular, euhedral amphibole crystals completely penetrate the occasional olivine grain. Minor patchy alteration of olivine to chondrodite was observed along the edges of some olivine grains. Serpentine and chlorite are also minor alteration products of the olivine.

The opaque mineral is probably magnetite. It is anhedral to subhedral and disseminated throughout. The mineral locally contains inclusions of carbonate, apatite, olivine, and biotite.

Sovite

The sovite contains from 50 to 100 percent carbonate, and the remaining components are various silicate and oxide minerals in widely varying proportions.

In thin section the rock is fine grained, massive, equigranular, hypidiomorphic to allotriomorphic, with straight to curved grain boundaries. The samples of nearly pure carbonate have an allotriomorphic texture.

The modal composition is estimated to be 50 to 100 percent carbonate, 0 to 10 percent apatite, 0 to 15 percent opaques, 0 to 15 percent biotite-phlogopite, 0 to 15 percent amphibole, and 0 to 8 percent olivine. In one specimen, clots of very fine-grained chlorite-amphibole alteration are present, but it is uncertain as to the nature of the original mineral.

The carbonate forms an interlocking mosaic of anhedral grains. Apatite forms anhedral to subhedral, round to round-elongate grains. The grains are locally concentrated into crude bands.

The opaque is likely magnetite. It occurs as anhedral to subhedral disseminated grains. The magnetite encloses rounded grains of carbonate. The magnetite occurs along (001) cleavage planes in biotite-phlogopite in one sample. In one specimen the magnetite is almost skeletal and in a second specimen, dusty, very fine-grained magnetite outlines altered former olivine grains.

The mica is biotite-phlogopite which commonly forms anhedral to subhedral tabular grains. The biotite also forms very fine-grained aggregates, possibly an alteration of an unknown mineral component. The (001) cleavage is bent in several of the larger tabular grains. The mineral also encloses irregular blebs of carbonate. Some of the larger grains have pleochroic, colourless to yellow-brown cores with colourless to dark red-brown rims, suggesting that the mica grains are compositionally zoned from a phlogopite core to a biotite rim.

The amphibole occurs as acicular, euhedral, generally colourless crystals. In one sample it occurs as very fine-grained interlocking masses outlined by dusty magnetite. These masses likely represent former olivine grains. Acicular crystals of amphibole completely penetrate associated olivine grains. Amphibole in some samples displays a pale green pleochroism.

The olivine occurs as anhedral rounded grains and it is sometimes penetrated by acicular crystals of amphibole. A local yellow patchy alteration, possibly to chondrodite, was observed along the edges of some grains and a red-brown alteration commonly occurs along fractures. The red-brown alteration is likely iddingsite. Minor alteration to serpentine and chlorite have also been observed.

Lamprophyre Dike Rock

One sample of a lamprophyre dike rock was examined in thin section. The rock has a fine-grained inequigranular-porphyritic-seriate texture. The mode is estimated as 10 percent carbonate, 10 percent opaques, 30 percent olivine, 40 percent amphibole, and 10 percent biotite.

The carbonate is anhedral and interstitial, and the opaques are anhedral to euhedral and disseminated throughout. The olivine phenocrysts have altered to carbonate and serpentine. The outline defined by the alteration products suggests the original olivine crystals were euhedral to subhedral.

The amphibole occurs as a very fine-grained mass of interlocking needles. Amphibole is the dominant matrix mineral. Biotite is present in minor quantities as very small grains closely associated with the amphibole.

From its composition, the dike rock is classified as an olivine lamprophyre.

PETROLOGY

Carbonatites, on the basis of fluid inclusion study and experiments in artificial systems (LeBas and Handley 1979; Hamilton *et al.* 1979; Freestone and Hamilton 1980), are currently considered to be products of liquid immiscibility. An aqueous alkali-rich carbonate phase is partitioned into one liquid and an alkali-rich silicate phase into a second, which by world-wide association likely approximates ijolite in composition (Rankin and LeBas 1974; LeBas *et al.* 1977). There is, to date, no evidence that an alkali-silicate phase is associated with the carbonatite rocks at the Borden Township Carbonatite Complex. Therefore, only one of two possible immiscible liquids is represented in the rocks found at the present level of exposure within the complex.

The presence of fenitized gneissic wall rocks indicates that the carbonatite magma has lost alkalies and iron during fenitization of the gneisses and that the present composition of the carbonate rocks must be considered a residuum.

The use of whole-rock chemical compositions (Appendix A, Tables A-2, A-3, B-2, B-3) to propose petrogenetic models, in systems in which liquid immiscibility is involved, is not recommended. The operation of cumulate and metasomatic processes and the unknown parentage of some samples add to the difficulty.

The norms in Appendices A and B (Tables A-4 and B-4) were calculated by the procedure outlined by LeBas (1973) and the statistical compositions of the lithologic units (Appendix C, Table C-1) were calculated by the procedure of Nie *et al.* (1975).

GEOCHRONOLOGY

The complex has recently been dated by Bell *et al.* (1987) at 1872 ± 13 Ma using $^{207}Pb/^{206}Pb$ techniques. The nearby Nemegosenda Lake and Lackner Lake alkalic rock complexes both contain carbonatite phases and were also dated as Proterozoic (1015 ± 63 Ma and 1138 ± 29 Ma respectively) by Bell and Blenkinsop (1980) using Rb-Sr isotope techniques.

METAMORPHISM

The gneissic wall rocks display well developed granoblastic textures, but their metamorphic rank is uncertain due to lack of indicator minerals. The country rocks are part of the Kapuskasing Subprovince of the Canadian Shield. Rocks within this subprovince are commonly of the upper amphibolite to granulite facies rank of regional metamorphism (Bennett *et al.* 1967; Thurston *et al.* 1977).

The samples collected from the drill core all display evidence of fenitization. Sodic pyroxene, sodic amphibole, biotite and carbonate have been added to the rocks. The mineralogy indicates that the fenitizing solution added sodium, iron, carbon dioxide and water to the rocks.

The porphyroblastic appearance of some feldspar and rarely some biotite grains in the gneisses and the development of a fine-grained granoblastic mosaic along feldspar-feldspar and feldspar-quartz grain boundaries is interpreted by the author to indicate that some recrystallization of the gneissic rocks most likely occurred at the time of fenitization.

In thin section the minerals of the carbonatite are usually fresh and display only minor amounts of alteration and no noticeable deformation or recrystallization. The carbonatite is considered by the author to be unmetamorphosed.

STRUCTURAL GEOLOGY

The Borden Township Carbonatite Complex lies within the Kapuskasing Subprovince of the Superior Province. This subprovince is characterized geophysically by a northeast-trending zone of gravity highs and pronounced linear aeromagnetic trends (Innes 1960, ODM-GSC 1970). This anomalous gravity zone has been interpreted as being due to an upwarp in the Conrad discontinuity caused by major regional faulting with the formation of a complex horst structure (Wilson and Brisbin 1965; Bennett *et al.* 1967). This prominent regional structure extends southward from the south end of Hudson Bay, becoming broader and more ill-defined as it approaches the Lake Superior Basin. The Borden Township Carbonatite Complex has been emplaced into the southern portion of this regional structure. The site of emplacement was likely controlled by one or more faults that characterize the Kapuskasing Subprovince.

Examination of the core indicates that fenites are intermixed with carbonatite. The complex likely consists of arcuate units of fenite and carbonatite, reflecting a cone sheet style of development. A sharp gneiss-carbonatite contact outlining the complex is unlikely. The contact shown on Figure 3 is located where the fenitized gneissic rocks become dominant. Brecciation, fracturing, and cone sheet carbonatite intrusion likely extended some distance into the wall rocks from the dominantly carbonate core of the carbonatite. Some sections of drill core appear to be breccia consisting of blocks of fenitized gneissic rock set in silicocarbonatite and sovite with well developed biotite-rich reaction rims up to 1 cm in width. Crude banding of the core defined by widely varying mineral content has a vertical or subvertical attitude.

Drilling and geophysical surveys by A.C.A. Howe International Limited have not completely delineated the limits of the carbonatite complex.

Drill logs for holes No. 1 and No. 2 indicate the presence of breccia zones. One breccia zone, 5.4 m wide, was encountered in hole No. 1 and was interpreted by the company to be due to a fault. This would suggest that the carbonatite complex has been subjected to some post-emplacement faulting.

GEOPHYSICS

The regional geophysical setting has been previously described under "Structural Geology". The complex is indicated by a prominent circular aeromagnetic anomaly approximately 1.6 km in diameter (see Figure 2). The complex has a surface area of approximately 4.1 km^2. A ground magnetic survey conducted by A.C.A. Howe International Limited over the carbonatite outlined peak intensity values ranging from 68,000 to 75,000 gammas. (Regional aeromagnetic surveys suggest a regional

background intensity of approximately 60,000 gammas.) Investigation of these anomalies by drilling and surface trenching has indicated that the anomalies are caused by magnetite.

A radiometric survey was undertaken by A.C.A. Howe International Limited using a TV-1 differential spectrometer. The data indicated strong topographic and physiographic control and failed to uncover any radioactive minerals. Higher response was noted where overburden coverage was not great and lower values are typical of the swampy areas.

RECOMMENDATIONS FOR FUTURE STUDY

Microprobe study of the mineral phases is needed so that proper petrologic modelling can be undertaken. Additional thin section study is also needed to better define the lithologies present. Additional work will be largely contingent on the completion of additional drilling by Hygrade Corrugated Containers Limited which would permit the collection of additional fresh rock samples.

Economic Geology

Carbonatite complexes are known to contain anomalous concentrations of several elements. Rare earths, uranium, niobium, zirconium and phosphorus are the most notable elements of interest in Ontario carbonatites. The Borden Township Carbonatite Complex commonly contains phosphorus in amounts between 2 and 8 percent P_2O_5 over wide drill core lengths. Uranium and niobium have also been identified in the complex. Weathering of a carbonatite can concentrate the more residual mineral phases such as apatite and pyrochlore, forming potentially economic concentrations. Weathering of a carbonatite may develop vermiculite and this mineral has been identified in the weathered surface debris of the complex. This complex occurs in the same geologic subprovince as the Cargill Township Carbonatite Complex where Cretaceous weathering has created a residual apatite deposit of 62,000,000 tons grading 19.6 percent P_2O_5 (Sandvik and Erdosh 1977).

PROPERTY DESCRIPTION

The early history of the Borden Township Carbonatite Complex has been summarized by Brewster and McCarthy (1977) as follows:

"Dominion Gulf Company entered the area in 1951 and flew airborne magnetic surveys. These surveys delineated anomalies in Borden Township and in the Nemegosenda Lake areas. R. Cunningham, a Dominion Gulf geologist, investigated the Borden anomaly but failed to locate any outcrop. In 1954, ground magnetometer, geological and radiometric surveys were conducted in the Nemegosenda Lake area northeast of the Borden Township Carbonatite. This work was followed by diamond drilling which resulted in the delineation of several deposits containing niobium and other minerals. The latter work was conducted under the direction of G.E. Parsons and progressed to the point of pilot plant metallurgical testing.

"Also in 1954, geologist D. Crossley made a strong effort to locate rock over the Borden Township aeromagnetic anomaly. Crossley discovered material that he identified as 'limestone boulders', which are now considered to be massive calcite ribs within calcite-mica-apatite carbonatite.

"In 1959, while working for Falconbridge Nickel Mines, G.E. Parsons undertook a surface investigation of the Borden aeromagnetic anomaly. The work consisted of magnetometer and geological surveys conducted along cut and chained grid lines. Several pits were dug in attempts to determine the cause of magnetic anomalies and to determine if the underlying rock contained minerals of economic interest. Analytical results of samples collected indicated the presence of significant apatite mineralization and unknown amounts of magnetite and vermiculite. No pyrochlore or niobium mineralization was encountered. Mr. Parsons recommended further investigation by diamond drilling."

A.C.A. HOWE INTERNATIONAL LIMITED [1978]

In 1977, A.C.A. Howe International Limited undertook a program to evaluate the mineral potential of the Borden Township Carbonatite Complex for Hygrade Corrugated Containers Limited. The program consisted of magnetometer and radiometric surveys on a 60 m cut grid covering the intrusion. The magnetometer survey outlined several areas of magnetic intensity and the radiometric survey, utilizing a differential spectrometer, delineated no anomalies. A geological survey completed in conjunction with the geophysical surveys failed to find outcrop.

Upon completion of the above surveys, bulldozer trenching of selected areas was undertaken. Ten trenches totalling 297 m were completed and five trenches reached weathered bedrock. The dominant rock exposed was calcitic carbonatite containing apatite, magnetite, amphibole, vermiculite or biotite-phlogopite and red-brown dolomite dikes. Assays of the weathered bedrock gave results varying from 1.0 to 9.0 percent P_2O_5.

In 1978, A.C.A. Howe International Limited completed six diamond drill holes, totalling 4700 feet (1410 m), for Facelle Company Limited (McCarthy and Brewster 1978).

TABLE 2. P_2O_5 ASSAYS OF DIAMOND DRILL CORE FROM THE BORDEN TOWNSHIP CARBONATITE COMPLEX. (Data from McCarthy and Brewster 1978).

Drill Hole	Intersection (feet)	Average P_2O_5 (percent)	Length (feet)
B1	574.4-588.4	4.78	14.0
	625.2-650.9	7.32	25.7
B2	110.2-160.1	6.05	49.9
	176.4-245.0	8.89	68.6
	251.9-329.7	12.78	77.8
	336.6-392.0	4.08	55.4
	481.0-507.0	3.40	26.0
	627.5-645.1	7.41	17.6
B3	96.3-119.6	4.11	23.3
	119.6-145.8	8.34	25.1
	145.8-164.7	4.92	18.9
	167.0-187.0	4.81	20.0
	202.0-710.0*	4.08	523.0
B4	26.5-150.0*	5.09	23.5
	158.0-225.0	1.89	67.0
	250.0-836.0*	5.61	586.0
B5	78.2-99.0	5.09	20.8
	103.5-117.5	7.05	14.0
	148.5-210.8	4.52	62.3
	245.3-305.5	6.14	60.2
	323.7-342.0	6.14	18.3
	342.0-358.0	3.90	16.0
B6	79.0-97.0	3.77	18.0
	97.0-125.0	4.37	28.0
	125.0-1034.0*	4.20	909.0

* While the data indicate that the assay average is not based on continuous sampling but is based on samples taken at intervals, the averages likely closely approximate the P_2O_5 content of the section.

Core assays defined zones of relatively high phosphorous content. Average phosphorous values for drill core are given in Table 2. These zones of phosphorous enrichment locally appear to correlate with core sections that are also magnetite rich. These phosphorous enriched zones, though interesting, are presently uneconomic.

Drilling has disclosed that the overburden thickness varies considerably over the complex. If weathering and solution of the carbonate has occurred, local concentrations of residual apatite are possible.

Magnetite occurs in a number of bands and gives rise to strong magnetic anomalies. The magnetite content is not sufficient to support a mining operation, but it could be a by-product of a mining operation.

Vermiculite is present in the weathered carbonatite and could be an extraction by-product of any residual apatite accumulations that are uncovered. No concentrations of vermiculite are known.

Uranium and niobium, presumably in pyrochlore, are encountered in two drill holes. Table 3 gives the uranium values encountered in these intersections.

TABLE 3. URANIUM ASSAYS OF CORE FROM DIAMOND DRILL HOLES 2B AND 5B ON THE BORDEN TOWNSHIP CARBONATITE COMPLEX. (Data from McCarthy and Brewster 1978).

Drill Hole	Intersection (feet)	U_3O_8 lb/ton	Length (feet)
B2	176.4-215.0	0.240	38.6
	251.9-264.0	0.403	12.1
B5	342.0-358.0	0.165	16.0

On the basis of assays, the uranium and niobium occur together suggesting their presence in the same mineral, possibly pyrochlore. In those sections containing uranium values, Nb_2O_5 values up to 598 ppm were reported (McCarthy and Brewster 1978).

RECOMMENDATIONS FOR THE PROSPECTOR

Examination of the surface of the complex for residual apatite is warranted. The carbonatite is enriched in phosphorous and while values now appear subeconomic, the reserves of phosphorous-bearing material are likely to be of future economic interest. Uranium and niobium mineralization have been identified and an attempt to delineate a zone of uranium-niobium mineralization appears to warrant consideration. Vermiculite and magnetite are present but they do not appear likely to support by themselves a potential mining operation but may have by-product significance. The complex contains phosphorous, uranium and niobium mineralization that warrants additional testing.

The lack of outcrop and the presence of thick overburden prevented mapping of surficial geology. The thick cover also inhibits radiometric surveys for the location of radioactive minerals. While magnetic surveys may be useful to determine general lithologic distribution and areas of magnetite concentration, the minerals of economic interest, apatite and pyrochlore, are non-magnetic. There is a weak correlation of increased apatite content with magnetite-rich sections.

The complex can only be adequately tested by systematic cross-sectional drilling.

Reference No. 1423
Sample No. B3 40.9-41.6
Fenitized gneiss.

Fine grained, equigranular, massive, allotriomorphic, with curved to straight grain boundaries. Carbonate is anhedral and interstitial. Amphibole is anhedral, and pleochroic from colourless to pale green. It is closely associated with pyroxene and may replace pyroxene. Pyroxene occurs as anhedral ragged pale green grains. Biotite forms large, irregular, tabular grains enclosing plagioclase, carbonate, and pyroxene. Biotite appears poikiloblastic. Plagioclase encloses anhedral, interstitial, clear grains and may enclose biotite. Plagioclase appears late and possibly recrystallized.

Reference No. 1424
Sample No. B3 76.2-76.9
Amphibole - biotite - pyroxene silicocarbonatite.

Fine grained, equigranular, massive, hypidiomorphic, with straight to curved grain boundaries. Carbonate is anhedral, interstitial, and has bent rhombohedral twin planes. Carbonate may enclose rounded pyroxene grains. Pyroxene consists of anhedral to subhedral, rounded grains with dark brown alteration along fractures. Biotite forms anhedral, irregular, tabular grains of brown colour. Bent (001) cleavage is common. Biotite locally encloses a feldspar or apatite grain. Amphibole is subhedral to euhedral, prismatic, and pale green in colour. Plagioclase is anhedral and occurs in large fractured grains and as small grains interlocking with other minerals. Smaller grains are poorly twinned. Plagioclase is likely xenocrystic. Larger grains were noted to enclose pyroxene.

Reference No. 1425
Sample No. B3 145.5-146.2
Amphibole-, biotite-, magnetite- and apatite-bearing sovite.

Fine grained, equigranular, massive, hypidiomorphic, with straight to serrate grain boundaries. Apatite forms rounded to rounded-elongate grains. Amphibole forms euhedral acicular grains, colourless to pale green in colour. Minor disseminated anhedral magnetite is present. Biotite forms small, subhedral, tabular, reddish brown grains. Carbonate is anhedral, interlocking with serrate grain boundaries.

Reference No. 1426
Sample No. B3 290.4-291.4
Amphibole- and biotite-bearing sovite.

Fine grained, massive, equigranular, hypidiomorphic, with curved to serrate grain boundaries. Amphibole is euhedral, acicular, and colourless to pale green in colour. Biotite occurs as fine-grained aggregates and as subhedral tabular grains. Apatite forms rounded to subrounded elongate grains. Carbonate forms an interlocking mosaic of grains with lobate to serrate grain boundaries.

Reference No. 1427
Sample No. B3 357.0-357.75
Biotite-bearing sovite.

Fine grained, massive, equigranular, hypidiomorphic, with straight to lobate grain boundaries. Biotite forms brown to reddish brown, tabular grains. Kink bands are present in some grains. Apatite forms rounded to rounded-elongate grains. Opaques form anhedral irregular grains and may occupy former fractures. Carbonate forms an interlocking mosaic of grains with curved to lobate boundaries.

Reference No. 1428
Sample No. B3 390.45-391.75
Olivine - magnetite - biotite - amphibole - apatite sovite.

Fine grained, equigranular, massive, hypidiomorphic, with curved to lobate grain boundaries. Opaques are anhedral, interstitial and may enclose carbonate grains. Amphibole forms acicular, euhedral, colourless grains. Apatite forms rounded to rounded-elongate grains. Olivine is fresh with dark brown alteration along edges and curved fractures. One grain appears to be completely penetrated by an amphibole crystal. Biotite forms anhedral to subhedral tabular grains and may enclose small grains of carbonate. Weak bending of (001) cleavage is present. Carbonate forms an anhedral mosaic of grains with curved lobate grain boundaries.

Reference No. 1429 (not analysed)
Sample No. B3 642.1-642.9
Apatite - amphibole - biotite - olivine - magnetite sovite.

Fine grained, massive, equigranular, hypidiomorphic, with straight to curved grain boundaries. Amphibole occurs in euhedral colourless acicular crystals. Amphibole penetrates completely through olivine grains. Apatite forms rounded to rounded-elongate grains. Olivine forms rounded anhedral grains. Yellowish alterations of olivine are possibly chondrodite. Dark reddish brown alteration occurs along edges and curved fractures. Biotite-phlogopite forms anhedral to subhedral, tabular grains pleochroic in brown to light brown. Opaques are anhedral and disseminated throughout. Carbonate forms an interlocking mosaic of grains with curved grain boundaries.

Reference No. 1430
Sample No. B4 32.6-37.5
Magnetite - apatite - biotite sovite.

Fine grained, massive, equigranular, hypidiomorphic, with curved grain boundaries. Opaques are anhedral, disseminated and often elongated. Apatite forms rounded to rounded-elongate grains. Biotite forms tabular, subhedral grains of pale yellow brown to reddish brown colour. Margins of some grains are slightly darker suggesting some compositional zoning. Carbonate forms an interlocking mosaic of anhedral grains with curved grain boundaries.

Reference No. 1431
Sample No. B4 104.5-104.75
Olivine - magnetite - apatite silicocarbonatite.

Fine grained, equigranular, massive,, hypidiomorphic, with curved grain boundaries. Apatite forms anhedral to euhedral, rounded to rounded-elongate grains. Olivine forms rounded anhedral grains; the grains are sometimes partially to completely altered to reddish iddingsite. Occasional amphibole grains may penetrate completely through olivine grains. Minor amounts of acicular euhedral, colourless amphibole are present. Opaques are anhedral, disseminated and may enclose small carbonate grains. Carbonate forms an interlocking mosaic of anhedral grains with curved grain boundaries.

Reference No. 1432
Sample No. B4 110.9-111.6
Amphibole - biotite-phlogopite - magnetite - olivine silicocarbonatite.

Fine to medium grained, equigranular, massive, hypidiomorphic, with straight to curved grain boundaries. Biotite forms anhedral tabular grains, pleochroic in light brown to dark reddish brown. Slight darkening of grain edges suggests compositional zoning. Some bending of (001) cleavage. Opaques are subhedral to euhedral and disseminated throughout. Some opaques enclose carbonate, olivine, and biotite. Olivine forms subhedral to euhedral grains with patchy alteration to chondrodite along edges of crystals. Amphibole crystals may penetrate through

olivine. Amphibole forms euhedral, acicular, colourless crystals. Carbonate forms anhedral, interlocking, interstitial grains with straight to curved grain boundaries.

Reference No. 1433
Sample No. B4 381.35-382.0
Apatite sovite.

Fine grained, equigranular, massive, hypidiomorphic, with curved grain boundaries. Apatite forms rounded to rounded-elongate grains subhedral in outline. Anhedral biotite is a minor component. Biotite is pleochroic in pale brown to brown. The grains are tabular and some enclose rounded carbonate grains. Minor amphibole occurs as euhedral, colourless, acicular crystals. Trace of opaques are present.

Reference No. 1434
Sample No. B4 406.3-406.9
Apatite - amphibole - biotite - magnetite - olivine silicocarbonatite.

Fine grained, massive, equigranular, hypidiomorphic, with curved to straight grain boundaries. Opaques are anhedral to euhedral in form and may enclose grains of carbonate, apatite, and biotite. Apatite forms rounded to rounded-elongated grains. Biotite forms tabular, subhedral to euhedral crystals; may enclose small inclusions of carbonate and apatite. Olivine forms subhedral to euhedral crystals, locally altered to yellow chondrodite and rarely to serpentine. Amphibole may penetrate the olivine grain. Amphibole forms euhedral, acicular, colourless grains. Carbonate is interstitial, anhedral, and has straight to curved grain boundaries.

Reference No. 1435
Sample No. B4 477.35-478.0
Biotite - amphibole - magnetite - olivine silicocarbonatite.

Fine to medium grained, equigranular, massive, hypidiomorphic, with straight to curved grain boundaries. Opaques are anhedral to euhedral, disseminated, and may contain small inclusions of anhedral apatite, carbonate, and biotite. Amphibole forms euhedral, acicular, colourless crystals. Biotite is euhedral to subhedral, pale brown to yellow brown. Slight concentric variation in colour suggests compositional zoning. It may enclose grains of carbonate and apatite. Olivine is anhedral to euhedral in crystal form. Patchy alteration to yellowish chondrodite occurs along margins of some grains. Olivine grains are penetrated by amphibole crystals. Olivine is altered to serpentine and greenish chlorite in places. Carbonate forms anhedral interlocking grains, interstitial to the other minerals.

Reference No. 1436
Sample No. B4 503.7-504.3
Biotite - magnetite - amphibole silicocarbonatite.

Fine to medium grained, equigranular, hypidiomorphic, with straight to curved grain boundaries. Biotite forms anhedral to euhedral grains and forms only a very minor component. Amphibole forms colourless, euhedral, acicular crystals. Opaques form anhedral to euhedral grains and may enclose anhedral carbonate and biotite. Carbonate is anhedral and interstitial to the other minerals.

Reference No. 1437
Sample No. B4 558.0-558.8
Amphibole - apatite sovite.

Fine grained, massive, equigranular, hypidiomorphic, with curved grain boundaries. Amphibole forms euhedral, acicular crystals and is colourless. Apatite forms rounded to rounded-elongate grains, which are commonly subhedral. Carbonate forms an interlocking mosaic of anhedral grains with curved grain boundaries.

Reference No. 1438
Sample No. B4 673.15-673.7
Amphibole - apatite - biotite-phlogopite silicocarbonatite.

Fine grained, massive, equigranular, hypidiomorphic, with curved grain boundaries. Amphibole is colourless, anhedral to subhedral, almost poikiloblastic in appearance with rounded carbonate and apatite inclusions. Biotite forms anhedral, tabular, irregularly shaped crystals, pleochroic in pale brown and dark reddish brown. Edges of grains are slightly darker than cores, implying compositional zoning. Carbonate forms abundant inclusions and biotite appears to be somewhat skeletal. Apatite forms anhedral to subhedral grains that are rounded to rounded-elongate. Opaques are minor and disseminated throughout.

Reference No. 1439
Sample No. B4 727.0-727.65
Amphibole - apatite - biotite sovite.

Fine grained, massive, equigranular, hypidiomorphic, with curved grain boundaries. Magnetite is anhedral, disseminated, and rarely occurs along biotite (001) cleavages. Biotite forms anhedral, irregular, tabular grains, pleochroic in light brown to dark reddish brown. Amphibole is anhedral to euhedral, acicular, and colourless. Apatite forms rounded to rounded-elongate grains that are anhedral to subhedral in outline. Carbonate forms an interlocking mosaic of anhedral grains.

Reference No. 1440
Sample No. B4 800.0-800.6
Amphibole - apatite - biotite - olivine silicocarbonatite.

Fine to medium grained, equigranular, massive, hypidiomorphic, with curved grain boundaries. Biotite-phlogopite forms anhedral irregular grains, pale yellow and dark reddish brown in colour. Colour variations in larger grains suggest some compositional variation. Amphibole occurs as colourless, euhedral, acicular crystals which may penetrate olivine grains completely. Apatite is anhedral to subhedral, rounded to rounded-elongate crystals. Olivine is subhedral to euhedral in outline. Minor alteration to yellowish chondrodite is evident on edges of some grains. Serpentine and chlorite are also present, and are rarely observed to contain small irregular carbonate grains. Minor opaques are disseminated throughout. Carbonate forms an interlocking mosaic of anhedral grains.

Reference No. 1441
Sample No. B5 31.6-32.2
Amphibole - biotite silicocarbonatite.

Fine grained, massive, equigranular, hypidiomorphic, with curved grain boundaries. Amphibole occurs as anhedral to euhedral, colourless to pale green crystals. Grains often appear poikiloblastic and contain irregular blebs of carbonate and small tabular biotite grains. Amphibole is strongly pleochroic from colourless to green. Biotite forms anhedral to subhedral tabular grains and in places encloses the odd magnetite, apatite, and carbonate grain. Trace amounts of colourless clinopyroxene are surrounded by amphibole. Apatite is present as rounded to rounded-elongate grains. Carbonate forms an interlocking interstitial mosaic of anhedral crystals.

Reference No. 1442
Sample No. B5 39.1-39.3
Fenitized gneiss.

Fine grained, equigranular, massive, hypidiomorphic, with curved grain boundaries. Amphibole forms ragged, colourless to pale green, prismatic crystals that are often interlocking. Carbonate is anhedral and interstitial. Biotite forms tabular, light brown grains. Plagioclase (An_{31}) is anhedral, often fractured and commonly veined with and containing carbonate inclusions. Plagioclase grain boundaries are commonly curved to lobate.

Reference No. 1443
Sample No. B5 135.6-136.4
Apatite - amphibole - biotite silicocarbonatite.

Fine grained, massive, equigranular, hypidiomorphic, with curved grain boundaries. Amphibole is anhedral to euhedral, prismatic, and pleochroic from colourless to pale green. Larger grains may contain inclusions of carbonate and appear poikiloblastic. Amphibole locally appears skeletal. Biotite forms anhedral to subhedral grains interlocking with each other. It contains the odd grain of apatite and carbonate. Apatite forms anhedral to subhedral, rounded to rounded-elongate grains. Carbonate forms an interlocking mosaic of anhedral grains.

Reference No. 1444
Sample No. B5 145.5-146.1
Apatite - amphibole - biotite silicocarbonatite.

Fine grained, massive, equigranular, hypidiomorphic, with curved grain boundaries. Biotite forms anhedral to subhedral, interlocking, tabular grains. Amphibole is anhedral to subhedral in form, pleochroic from colourless to pale green. Locally amphibole is skeletal in appearance and encloses carbonate. Carbonate is anhedral and interstitial. Apatite forms rounded to rounded-elongate grains.

Reference No. 1445 (not analysed)
Sample No. B5 214.0-214.5
Apatite sovite.

Fine grained, massive, equigranular, hypidiomorphic, with straight to curved grain boundaries. Apatite forms anhedral, rounded to rounded-elongate grains. Carbonate forms an interlocking mosaic of anhedral grains.

Reference No. 1446
Sample No. B5 468.45-469.0
Fenitized gneiss.

Fine grained, massive, equigranular, granoblastic, with curved grain boundaries. Biotite forms anhedral to subhedral grains, tabular and irregular in form. Biotite is intergranular. Minor amphibole is pleochroic from colourless to pale green, and is prismatic. Minor interstitial carbonate is present. Quartz forms anhedral, interlocking grains and displays well developed triple junction grain contacts. Plagioclase (An_{26-29}) is anhedral and interlocking. Edges of grains are turbid; some carbonate and amphibole alteration is present.

Reference No. 1447
Sample No. B5 521.4-522.0
Olivine lamprophyre dike.

Fine grained, inequigranular, porphyritic seriate. Carbonate is fine grained and interstitial. Opaques are anhedral to subhedral and disseminated. Olivine is totally altered to carbonate and serpentine. Olivine is euhedral to subhedral in form. Amphibole is present as a fine-grained mat of prismatic crystals. Amphibole dominates groundmass minerals. Biotite is present in the groundmass, mixed in with amphibole. All phenocrysts are olivine.

Reference No. 1448
Sample No. B5 584.65-585.25
Fenitized gneiss.

Fine grained, massive, equigranular, granoblastic, with curved grain boundaries. Biotite forms anhedral, irregular, tabular grains. Quartz is irregular, forms a mosaic, and is granoblastic with triple junction points. Plagioclase is anhedral, flecked with sericite and carbonate. Locally plagioclase-quartz grain boundaries are very fine grained, recrystallized, and granoblastic. Traces of green acicular amphibole occur along grain boundaries.

Reference No. 1449
Sample No. B6 30.1-30.7
Apatite - biotite - amphibole silicocarbonatite.

Fine grained, equigranular, massive, hypidiomorphic, with straight to curved grain boundaries. Biotite forms anhedral, tabular grains of irregular outline. Light yellow brown cores and dark reddish brown rims indicate some compositional zoning. Amphibole is anhedral to euhedral, and pleochroic in colourless to pale green. Skeletal amphibole encloses carbonate and interlocks with biotite. Biotite (001) cleavage is parallel to long axis of amphibole. Apatite occurs as anhedral to subhedral, rounded to rounded-elongate grains. Carbonate is anhedral, forming an interlocking mosaic.

Reference No. 1450
Sample No. B6 329.0-329.6
Biotite - apatite - amphibole - magnetite sovite.

Fine grained, equigranular, massive, hypidiomorphic, with straight to curved grain boundaries. Biotite forms tabular, anhedral grains. Opaques are anhedral, locally appear skeletal. Minor dusty opaque grains enclose fine grained mats of amphibole that may be after skeletal olivine. Amphibole forms acicular crystals, commonly in interlocking clots that may be after former olivine. Apatite is anhedral to subhedral, rounded to rounded-elongate. Carbonate forms a mosaic of anhedral interlocking grains.

Reference No. 1451
Sample No. B6 530.1-530.8
Magnetite - amphibole - apatite sovite.

Fine grained, equigranular, massive, hypidiomorphic, with straight to curved grain boundaries. Magnetite is anhedral and disseminated. Amphibole is subhedral to euhedral, acicular, colourless and occurs evenly distributed throughout. Apatite is anhedral to subhedral, rounded to rounded-elongate grains. Carbonate is a mosaic of anhedral interlocking grains.

Reference No. 1452
Sample No. B6 554.2-555.0
Apatite - amphibole - biotite silicocarbonatite.

Fine grained, equigranular, massive, hypidiomorphic, with straight to curved grain boundaries. Amphibole forms subhedral to euhedral, acicular, colourless crystals. Biotite forms tabular, anhedral to subhedral grains which commonly enclose small opaque grains. Apatite forms rounded to rounded-elongate grains. Carbonate forms anhedral interstitial grains.

Reference No. 1453
Sample No. B6 620.1-620.75
Biotite - amphibole - apatite sovite.

Fine grained, massive, equigranular, hypidiomorphic, with curved to straight grain boundaries. Amphibole forms euhedral to subhedral ragged grains. Generally colourless but larger crystals display irregular replacement by a secondary amphibole, pleochroic in pale green. Biotite forms anhedral, tabular brown grains. Apatite forms anhedral, rounded to subrounded grains disseminated throughout. Carbonate forms a mosaic of interlocking grains.

Reference No. 1454
Sample No. B6 644.8-645.55
Apatite sovite.

Fine grained, massive, inequigranular-seriate, hypidiomorphic, with straight to curved grain boundaries. Amphibole occurs in minor amounts as acicular crystals. Minor chlorite-amphibole alteration occurs in irregular patches. Apatite forms an-

hedral to subhedral, rounded to rounded-elongate grains. Carbonate forms an interlocking mosaic of anhedral grains.

Reference No. 1455 (not analysed)
Sample No. B6 690.1-691.2
Biotite - amphibole silicocarbonatite.

Very fine grained, equigranular, massive, hypidiomorphic, with curved to straight grain boundaries. Biotite forms anhedral ragged grains. Amphibole forms fibrous, acicular crystals which interlock into a matted mass. Carbonate is anhedral and interstitial.

Reference No. 1456
Sample No. B6 793.1-793.8
Apatite sovite.

Fine grained, equigranular, massive, allotriomorphic, with curved grain boundaries. Apatite forms anhedral, rounded to rounded-elongate grains. Traces of opaques and biotite-phlogopite are present.

Reference No. 1457
Sample No. B6 892.0-892.65
Amphibole - apatite - biotite - olivine silicocarbonatite.

Fine to medium grained, massive, inequigranular-seriate, hypidiomorphic, with straight to curved grain boundaries. Amphibole forms euhedral, acicular, colourless crystals. Olivine forms anhedral, rounded to irregular-rounded grains with traces of serpentine and chlorite. Minor euhedral sphene has well developed concentric zoning. Apatite forms anhedral to subhedral, rounded to rounded-elongate grains. Biotite forms anhedral to euhedral, irregular, tabular grains. The grains are pleochroic with yellow brown cores and dark reddish brown rims. Zoning suggests variation in composition across the grain. Biotite has been observed to enclose irregular blebs of carbonate, rarely small grains of sphene. Carbonate forms an interlocking mosaic of anhedral grains.

Reference No. 1458
Sample No. B6 915.2-915.85
Olivine - amphibole - magnetite - apatite sovite.

Fine grained, equigranular, massive, hypidiomorphic, with curved to straight grain boundaries. Olivine forms minor rounded, anhedral grains. Minor alteration to serpentine chlorite and acicular amphibole. Magnetite forms anhedral to subhedral disseminated grains. Amphibole forms euhedral, colourless, acicular crystals. Apatite occurs as anhedral to subhedral, rounded to rounded-elongate grains.

Reference No. 1459
Sample No. B6 988.15-988.95
Apatite sovite.

Fine grained, equigranular, massive, allotriomorphic, with curved grain boundaries. Apatite forms rounded to rounded-elongate grains of anhedral to subhedral form. Carbonate forms a mosaic of interlocking anhedral grains.

TABLE A-2. MAJOR ELEMENT ANALYSES OF WHOLE-ROCK SAMPLES FROM DRILL CORE, COLLECTED IN 1979 FROM THE BORDEN TOWNSHIP CARBONATITE COMPLEX. LOCATIONS OF DRILL HOLES ARE SHOWN ON FIGURE 3 (CHART A).

	SOVITE					
Ref. No.	**1425**	**1426**	**1427**	**1428**	**1430**	**1433**
SiO_2	1.83	0.75	1.53	2.87	0.0	0.20
Al_2O_3	0.49	0.32	0.72	0.51	0.60	0.26
Fe_2O_3	1.69	0.31	1.32	1.54	3.50	0.55
FeO	2.58	1.91	2.41	2.66	4.16	1.50
MgO	3.27	2.54	2.21	3.63	3.08	2.94
CaO	45.70	47.00	46.20	45.00	43.70	47.70
Na_2O	0.67	0.65	0.63	0.74	0.72	0.68
K_2O	0.39	0.15	0.52	0.23	0.10	0.07
TiO_2	0.09	0.0	0.09	0.08	0.16	0.0
P_2O_5	3.57	3.23	5.34	4.84	4.68	6.17
S	0.28	0.50	0.15	0.22	0.25	0.09
MnO	0.14	0.12	0.11	0.13	0.21	0.15
CO_2	38.00	42.00	37.20	37.00	37.90	39.20
H_2O^+	0.0	0.0	0.10	0.11	0.0	0.04
H_2O^-	0.28	0.45	0.31	0.23	0.32	0.25
Sum	98.98	99.93	98.84	99.79	99.38	99.80
Specific Gravity	2.83	2.80	2.83	2.84	2.91	2.83

	SOVITE					
Ref. No.	**1437**	**1439**	**1418**	**1450**	**1451**	**1453**
SiO_2	0.0	2.02	0.0	3.48	2.84	3.22
Al_2O_3	0.19	0.46	0.45	0.81	1.04	0.39
Fe_2O_3	0.0	2.82	0.0	2.65	2.50	2.51
FeO	1.16	3.00	1.66	2.41	2.58	2.25
MgO	2.62	4.05	2.35	5.38	3.33	4.57
CaO	49.20	43.70	48.00	41.10	44.20	43.60
Na_2O	0.65	0.64	0.68	0.86	0.76	0.83
K_2O	0.03	0.29	0.0	0.27	0.22	0.20
TiO_2	0.0	0.14	0.0	0.05	0.12	0.06
P_2O_5	1.17	5.75	0.05	5.36	3.94	5.21
S	0.06	0.27	0.11	0.16	0.22	0.18
MnO	0.20	0.17	0.32	0.24	0.18	0.20
CO_2	49.90	35.10	45.30	36.50	37.50	35.70
H_2O^+	0.0	0.43	0.0	0.01	0.17	0.05
H_2O^-	0.21	0.10	0.33	0.31	0.16	0.17
Sum	100.39	98.94	99.25	99.59	99.76	99.14
Specific Gravity	2.77	2.88	2.77	2.87	2.84	2.85

Notes: For sample descriptions, see Table A-1. Analyses by Geoscience Laboratories, Ontario Geological Survey, Toronto.

Ref. No.	**Sample No.**	**Ref. No.**	**Sample No.**
1425	B3 145.5-146.2	1437	B4 558.0-558.8
1426	B3 290.4-291.4	1439	B4 727.0-727.65
1427	B3 357.0-357.75	1418	B2 454.8-455.6
1428	B3 390.45-391.75	1450	B6 329.0-329.6
1430	B4 32.6-37.5	1451	B6 530.1-530.8
1433	B4 381.35-382.0	1453	B6 620.1-620.75

TABLE A-2. Continued.

	SOVITE				LAMPRO-PHYRE	FENITE
Ref. No.	**1454**	**1456**	**1458**	**1459**	**1447**	**1415**
SiO_2	5.53	0.0	2.51	13.10	34.30	61.60
Al_2O_3	0.38	0.70	0.62	0.60	6.33	15.0
Fe_2O_3	1.97	0.0	3.23	0.0	3.90	2.15
FeO	2.41	1.08	2.91	0.75	9.73	3.08
MgO	3.86	2.13	3.78	2.12	13.00	2.99
CaO	43.70	48.70	43.30	43.70	12.50	3.47
Na_2O	1.03	0.54	0.67	0.35	1.55	6.69
K_2O	0.03	0.0	0.18	0.05	3.63	2.60
TiO_2	0.07	0.0	0.13	0.0	3.65	0.59
P_2O_5	3.66	0.77	6.26	0.58	0.64	0.16
S	0.28	0.09	0.35	0.01	0.26	0.10
MnO	0.17	0.14	0.16	0.13	0.28	0.08
CO_2	34.70	45.30	34.50	38.90	7.97	1.15
H_2O^+	0.16	0.0	0.23	0.01	0.73	0.11
H_2O^-	0.23	0.23	0.10	0.11	0.27	0.42
Sum	98.18	99.68	98.93	100.41	98.74	100.19
Specific Gravity	2.88	2.74	2.86	2.74	3.07	2.78

	FENITE					
Ref. No.	**1416**	**1417**	**1446**	**1448**	**1419**	**1420**
SiO_2	57.80	58.60	61.30	67.70	51.00	49.90
Al_2O_3	16.20	16.30	18.30	17.80	15.50	13.10
Fe_2O_3	3.24	2.44	0.97	0.02	2.58	2.68
FeO	1.75	1.75	3.16	0.67	6.57	5.49
MgO	2.76	2.66	1.48	0.56	3.73	6.73
CaO	3.90	4.79	4.41	3.32	10.40	5.94
Na_2O	8.30	8.47	6.11	5.72	5.39	6.43
K_2O	2.34	1.78	1.79	1.40	0.76	2.98
TiO_2	0.47	0.42	0.49	0.14	0.93	0.89
P_2O_5	0.13	0.20	0.23	0.03	0.05	0.38
S	0.04	0.05	0.07	0.03	0.76	0.42
MnO	0.08	0.10	0.07	0.01	0.18	0.17
CO_2	1.94	1.91	1.01	0.72	1.12	3.14
H_2O^+	0.18	0.22	0.61	0.0	0.21	0.42
H_2O^-	0.49	0.36	0.05	0.47	0.29	0.31
Sum	99.62	100.05	100.05	98.59	99.47	98.98
Specific Gravity	2.78	2.77	2.72	2.64	3.00	2.85

Notes: For sample descriptions, see Table A-1. Analyses by Geoscience Laboratories, Ontario Geological Survey, Toronto.

Ref. No.	Sample No.	Ref. No.	Sample No.
1454	B6 644.8-645.55	1416	B1 465.5-465.9
1456	B6 793.1-793.8	1417	B1 675.1-676.2
1458	B6 915.2-915.85	1446	B5 468.45-469.0
1459	B6 988.15-988.95	1448	B5 584.65-585.25
1447	B5 521.4-522.0	1419	B2 468.0-468.7
1415	B1 78.7-79.2	1420	B2 601.2-601.7

TABLE A-2. Continued.

	FENITE		SILICOCARBONATITE			
Ref. No.	**1423**	**1442**	**1421**	**1422**	**1424**	**1441**
SiO_2	39.90	28.70	34.90	27.30	41.70	0.0
Al_2O_3	7.01	7.10	10.70	3.34	6.02	0.11
Fe_2O_3	3.91	2.70	2.02	3.33	4.50	0.0
FeO	6.74	8.82	5.40	3.49	6.57	3.33
MgO	11.50	10.40	18.30	7.75	12.70	18.00
CaO	14.10	16.50	9.12	27.10	13.80	30.40
Na_2O	2.83	1.98	0.80	2.68	2.70	0.40
K_2O	4.28	5.38	8.15	2.17	3.69	0.0
TiO_2	0.50	0.75	0.14	0.23	0.49	0.0
P_2O_5	2.77	1.25	2.77	3.95	1.86	1.83
S	0.01	0.36	0.02	0.02	0.04	0.0
MnO	0.23	0.30	0.17	0.21	0.23	0.35
CO_2	5.12	14.10	5.04	18.20	3.94	46.50
H_2O^+	0.44	0.72	0.69	0.02	0.61	0.08
H_2O^-	0.30	0.16	0.30	0.26	0.23	0.05
Sum	99.64	99.22	98.52	100.06	99.08	101.05
Specific Gravity	3.06	2.94	2.90	2.98	3.07	2.91

	SILICOCARBONATITE					
Ref. No.	**1431**	**1432**	**1434**	**1435**	**1436**	**1438**
SiO_2	12.10	19.10	12.00	15.60	18.20	33.0
Al_2O_3	0.78	0.74	1.10	0.84	0.90	3.68
Fe_2O_3	7.51	24.20	24.10	29.40	31.60	2.27
FeO	8.99	17.60	15.10	18.10	16.60	6.32
MgO	10.70	15.80	11.40	12.00	8.30	11.70
CaO	30.00	9.05	16.70	10.10	10.60	19.60
Na_2O	0.68	1.05	0.22	1.06	1.92	2.62
K_2O	0.11	0.56	0.37	0.41	0.70	2.82
TiO_2	0.55	1.89	2.23	2.42	2.75	0.30
P_2O_5	2.73	0.15	1.01	2.27	0.14	3.37
S	0.07	0.18	0.15	0.13	8.35	0.02
MnO	0.34	0.57	0.45	0.45	0.35	0.20
CO_2	23.50	8.07	4.12	6.93	8.07	12.40
H_2O^+	0.73	1.65	1.03	0.82	0.35	0.62
H_2O^-	0.12	0.35	0.35	0.17	0.10	0.26
Sum	98.91	100.96	90.33	100.70	108.93	99.18
Specific Gravity	3.08	3.54	3.59	3.71	3.65	2.95

Notes: For sample descriptions, see Table A-1. Analyses by Geoscience Laboratories, Ontario Geological Survey, Toronto.

Ref. No.	Sample No.	Ref. No.	Sample No.
1423	B3 40.9-41.6	1431	B4 104.5-104.75
1442	B5 39.1-39.3	1432	B4 110.9-111.6
1421	B2 677.3-677.8	1434	B4 406.3-406.9
1422	B3 17.4-17.9	1435	B4 477.35-478.0
1424	B3 76.2-76.9	1436	B4 503.7-504.3
1441	B5 31.6-32.2	1438	B4 673.15-673.7

TABLE A-2. Continued.

	SILICOCARBONATITE					
Ref. No.	**1440**	**1443**	**1444**	**1449**	**1452**	**1457**
SiO_2	15.60	29.40	37.90	32.20	26.10	22.20
Al_2O_3	0.86	7.27	6.71	3.68	2.10	0.76
Fe_2O_3	7.10	1.14	2.87	2.76	9.59	5.81
FeO	8.82	5.91	5.49	4.41	5.32	4.49
MgO	13.10	14.70	16.20	12.40	16.70	10.30
CaO	27.00	15.90	10.90	19.00	16.10	26.70
Na_2O	0.44	0.92	2.72	3.29	1.57	2.31
K_2O	0.80	6.54	5.88	3.72	2.11	1.09
TiO_2	0.58	0.49	0.39	0.20	1.12	0.29
P_2O_5	3.88	1.98	2.24	3.03	1.07	0.10
S	0.36	0.07	0.03	0.03	0.22	0.22
MnO	0.34	0.16	0.18	0.22	0.32	0.19
CO_2	20.30	13.60	7.02	14.30	14.80	24.30
H_2O^+	1.10	0.42	0.84	0.14	1.69	0.16
H_2O^-	0.12	0.16	0.12	0.33	0.40	0.18
Sum	100.40	98.66	99.49	99.71	99.21	99.10
Specific Gravity	3.09	2.87	2.92	2.94	2.99	2.95

Notes: For sample descriptions, see Table A-1. Analyses by Geoscience Laboratories, Ontario Geological Survey, Toronto.

Ref. No.	Sample No.	Ref. No.	Sample No.
1440	B4 800.0-800.6	1449	B6 30.1-30.7
1443	B5 135.6-136.4	1452	B6 554.2-555.0
1444	B5 145.5-146.1	1457	B6 892.0-892.65

TABLE A-3. TRACE ELEMENT ANALYSES OF WHOLE-ROCK SAMPLES FROM DRILL CORE, COLLECTED IN 1979 FROM THE BORDEN TOWNSHIP CARBONATITE COMPLEX. LOCATIONS OF DRILL HOLES ARE SHOWN ON FIGURE 3 (CHART A).

	SOVITE					
Ref. No.	**1425**	**1426**	**1427**	**1428**	**1430**	**1433**
Ag	12	1	6	1	1	1
Au						
As						
Ba	270	240	240	270	220	240
Be	1	1	1	1	1	1
Bi						
Co	14	16	9	12	11	7
Cr	8	6	10	5	7	8
Cu	8	11	11	10	8	8
Ga	22	7	27	16	10	5
Hg						
Li	4	3	3	<3	3	<3
Mn						
Mo	<3	<3	<3	<3	<3	<3
Nb	<30	<30	<30	<30	<30	<30
Ni	<5	<5	<5	<5	<5	<5
Pb	15	13	11	11	16	17
Rb	10	<10	20	10	<10	<10
Sb						
Sc	<5	<5	<5	5	6	<5
Sn	2	1	3	2	9	3
Sr	4000	4500	4000	4500	5000	5000
Ti						
V	40	<10	60	45	150	20
Y	100	100	100	100	100	100
Zn	40	18	34	42	53	20
Zr	200	8	25	15	600	<10
La	250	250	250	200	200	200
Nd	130	120	120	120	110	120
Ce	240	230	230	230	210	210
Yb	4	5	5	4	5	4

Notes: For sample descriptions, see Table A-1. Analyses by Geoscience Laboratories, Ontario Geological Survey, Toronto.

Ref. No.	**Sample No.**	**Ref. No.**	**Sample No.**
1425	B3 145.5-146.2	1428	B3 390.45-391.75
1426	B3 290.4-291.4	1430	B4 32.6-37.5
1427	B3 357.0-357.75	1433	B4 381.35-382.0

TABLE A-3. Continued.

	SOVITE					
Ref. No.	**1437**	**1439**	**1418**	**1450**	**1451**	**1453**
Ag	1	1		1	1	1
Au						
As						
Ba	250	240	310	280	240	240
Be	1	1		1	1	1
Bi						
Co	<5	17	5	12	11	11
Cr	6	8	6	11	27	9
Cu	6	8	10	6	10	12
Ga	2	20		14	15	12
Hg						
Li	<3	<3	<3	4	<3	<3
Mn						
Mo	<3	<3	<3	<3	<3	<3
Nb	<30	<30	<30	<30	<30	<30
Ni	<5	<5	<5	<5	<5	<5
Pb	15	16	13	15	11	14
Rb	<10	10	<10	10	10	<10
Sb						
Sc	<5	5	7	<5	6	<5
Sn	3	39		8	7	6
Sr	6000	4500	4500	7000	6000	6000
Ti						
V	<10	70	<10	35	70	45
Y	100	100	100	90	90	90
Zn	24	44	11	24	43	43
Zr	25	10	<10	10	15	20
La	150	200	150	200	200	150
Nd	90	120	120	120	110	100
Ce	180	220	210	210	190	190
Yb	7	6	6	5	5	5

Notes: For sample descriptions, see Table A-1. Analyses by Geoscience Laboratories, Ontario Geological Survey, Toronto.

Ref. No.	**Sample No.**	**Ref. No.**	**Sample No.**
1437	B4 558.0-558.8	1450	B6 329.0-329.6
1439	B4 727.0-727.65	1451	B6 530.1-530.8
1418	B2 454.8-455.6	1453	B6 620.1-620.75

TABLE A-3. Continued.

	SOVITE				LAMPROPHYRE	FENITE	
Ref. No.	**1454**	**1456**	**1458**	**1459**	**1447**	**1415**	**1416**
Ag	1	1	1	1	1	1	1
Au							
As							
Ba	300	310	260	300	610	1440	1400
Be	4	1	1	1	19	1	3
Bi							
Co	12	<5	14	<5	59	21	18
Cr	6	5	8	7	700	149	139
Cu	10	20	11	6	148	54	34
Ga	8	4	13	4	120	26	23
Hg							
Li	<3	<3	<3	<3	24	10	12
Mn							
Mo	<3	<3	<3	<3	<1	<1	<1
Nb	<30	<30	<30	<30	80	<30	<30
Ni	<5	<5	<5	<5	420	57	51
Pb	15	13	14	10	11	17	16
Rb	<10	<10	<10	<10	230	80	50
Sb							
Sc	<5	<5	10	<5	20	15	8
Sn	1	1	6	1	31	1	1
Sr	5000	7000	4000	4000	800	500	500
Ti							
V	45	<10	70	<10	400	90	90
Y	100	100	90	90	30	<10	<10
Zn	45	12	46	10	116	102	96
Zr	100	50	25	45	200	150	200
La	200	150	200	200	<100	<100	<100
Nd	120	100	120	90	60	30	40
Ce	200	190	200	170	100	80	90
Yb	6	6	4	4	1	<1	<1

Notes: For sample descriptions, see Table A-1. Analyses by Geoscience Laboratories, Ontario Geological Survey, Toronto.

Ref. No.	Sample No.	Ref. No.	Sample No.
1454	B6 644.8-645.55	1447	B5 521.4-522.0
1456	B6 793.1-793.8	1415	B1 78.7-79.2
1458	B6 915.2-915.85	1416	B1 465.5-465.9
1459	B6 988.15-988.95		

TABLE A-3. Continued.

	FENITE						
Ref. No.	**1417**	**1446**	**1448**	**1419**	**1420**	**1423**	**1442**
Ag	1	1	1	1	1	1	1
Au							
As							
Ba	1100	700	770	580	1100	500	1000
Be	4	3	2	1	3	3	2
Bi							
Co	14	8	<5	58	42	21	51
Cr	96	16	7	233	228	33	293
Cu	21	16	18	180	240	5	133
Ga	25	24	31	18	24	22	8
Hg							
Li	8	8	4	11	9	10	6
Mn							
Mo	<1	<1	<1	<1	<1	<1	<1
Nb	<30	<30	<30	<30	100	150	150
Ni	42	5	7	108	186	10	126
Pb	13	13	11	<10	14	<10	10
Rb	30	60	30	10	90	90	100
Sb							
Sc	8	<5	<5	50	20	15	30
Sn	1	1	2	1	2	3	1
Sr	500	500	600	250	500	600	1500
Ti							
V	60	30	<10	350	100	60	200
Y	<10	<10	<10	30	40	25	45
Zn	74	91	24	102	160	160	160
Zr	100	250	20	60	100	1000	250
La	<100	<100	<100	<100	<100	<100	<100
Nd	50	30	10	10	50	50	60
Ce	110	80	10	20	80	80	120
Yb	<1	<1	<1	2	2	<1	2

Notes: For sample descriptions, see Table A-1. Analyses by Geoscience Laboratories, Ontario Geological Survey, Toronto.

Ref. No.	**Sample No.**	**Ref. No.**	**Sample No.**
1417	B1 675.1-676.2	1420	B2 601.2-601.7
1446	B5 468.45-469.0	1423	B3 40.9-41.6
1448	B5 584.65-585.25	1442	B5 39.1-39.3
1419	B2 468.0-468.7		

TABLE A-3. Continued.

	SILICOCARBONATITE					
Ref. No.	**1421**	**1422**	**1424**	**1441**	**1431**	**1432**
Ag						
Au						
As						
Ba	1200	400	370	80	170	110
Be						
Bi						
Co	19	14	25	5	30	56
Cr	12	84	93	7	8	7
Cu	6	8	12	6	7	6
Ga						
Hg						
Li	6	4	10	<3	4	4
Mn						
Mo	<1	<3	<1	<3	<3	4
Nb	300	70	90	<30	30	70
Ni	<5	12	22	<5	<5	<5
Pb	<10	<10	<10	11	13	<10
Rb	140	50	90	<10	<10	20
Sb						
Sc	<5	20	20	15	10	6
Sn						
Sr	800	3000	600	3000	3000	600
Ti						
V	15	35	40	<10	200	600
Y	30	70	25	25	70	20
Zn	170	98	140	26	150	340
Zr	100	450	800	<10	1500	1500
La	<100	<100	<100	<100	<100	<100
Nd	60	120	40	40	100	30
Ce	110	210	70	80	200	90
Yb	<1	3	<1	<1	3	4

Notes: For sample descriptions, see Table A-1. Analyses by Geoscience Laboratories, Ontario Geological Survey, Toronto.

Ref. No.	**Sample No.**	**Ref. No.**	**Sample No.**
1421	B2 677.3-677.8	1441	B5 31.6-32.2
1422	B3 17.4-17.9	1431	B4 104.5-104.75
1424	B3 76.2-76.9	1432	B4 110.9-111.6

TABLE A-3. Continued.

	SILICOCARBONATITE				
Ref. No.	**1434**	**1435**	**1436**	**1438**	**1440**
Ag					
Au					
As					
Ba	80	80	120	390	170
Be					
Bi					
Co	44	54	51	16	42
Cr	13	14	12	26	14
Cu	8	7	16	6	38
Ga					
Hg					
Li	5	4	<3	6	<3
Mn					
Mo	4	3	3	<1	<3
Nb	60	60	60	70	<30
Ni	<5	<5	<5	<5	7
Pb	<10	<10	<10	<10	<10
Rb	20	10	<10	80	30
Sb					
Sc	9	10	20	25	2
Sn					
Sr	900	600	700	1500	2500
Ti					
V	700	1000	900	50	150
Y	45	25	20	45	60
Zn	300	420	360	110	150
Zr	300	900	800	1000	100
La	<100	<100	<100	<100	<100
Nd	110	50	30	80	90
Ce	180	90	50	140	180
Yb	5	6	5	2	3

Notes: For sample descriptions, see Table A-1. Analyses by Geoscience Laboratories, Ontario Geological Survey, Toronto.

Ref. No.	Sample No.	Ref. No.	Sample No.
1434	B4 406.3-406.9	1438	B4 673.15-673.7
1435	B4 477.35-478.0	1440	B4 800.0-800.6
1436	B4 503.7-504.3		

TABLE A-3. Continued.

	SILICOCARBONATITE				
Ref. No.	**1443**	**1444**	**1449**	**1452**	**1457**
Ag					
Au					
As					
Ba	660	490	380	440	190
Be					
Bi					
Co	24	18	11	78	16
Cr	216	54	46	1120	7
Cu	26	5	5	74	11
Ga					
Hg					
Li	5	11	6	4	<3
Mn					
Mo	<1	<1	<1	<1	<3
Nb	100	200	100	50	<30
Ni	52	8	5	600	<5
Pb	13	<10	<10	<10	<10
Rb	100	130	100	60	20
Sb					
Sc	9	20	30	25	50
Sn					
Sr	1500	700	2500	1000	2500
Ti					
V	50	50	45	100	100
Y	45	25	50	40	50
Zn	108	140	92	160	75
Zr	200	300	500	100	7000
La	<100	<100	<100	<100	<100
Nd	50	50	70	60	70
Ce	90	90	130	120	130
Yb	1	<1	2	2	3

Notes: For sample descriptions, see Table A-1. Analyses by Geoscience Laboratories, Ontario Geological Survey, Toronto.

Ref. No.	**Sample No.**	**Ref. No.**	**Sample No.**
1443	B5 135.6-136.4	1452	B6 554.2-555.0
1444	B5 145.5-146.1	1457	B6 892.0-892.65
1449	B6 30.1-30.7		

TABLE A-4. NORMATIVE MINERALS (ALKALIC ROCKS) FOR WHOLE-ROCK SAMPLES COLLECTED IN 1979 FROM THE BORDEN TOWNSHIP CARBONATITE COMPLEX.

	SOVITE					
Ref. No.	**1425**	**1426**	**1427**	**1428**	**1430**	**1433**
Quartz	0.0	0.0	0.0	0.0	0.0	0.0
Corundum	0.0	0.16	0.0	0.0	0.10	0.0
Orthoclase	0.0	0.0	0.0	1.07	0.0	0.0
Albite	0.0	0.0	0.0	0.54	0.0	0.0
Leucite	0.18	0.0	0.0	0.0	0.0	0.0
Kalsilite	1.10	0.50	1.58	0.0	0.0	0.04
Nepheline	0.26	0.0	0.60	0.60	1.24	0.70
Carnegieite	0.0	0.0	0.0	0.0	0.18	0.0
Na_2SiO_3	0.0	0.0	0.0	0.0	0.0	0.36
Acmite	0.65	0.0	1.82	1.16	0.0	1.59
Thenardite	1.24	1.49	0.66	0.97	1.11	0.40
Gehlenite	0.0	0.0	0.0	0.0	0.0	0.0
Akermanite	0.0	0.0	0.0	0.0	0.0	0.0
Fe-Aker.	0.0	0.78	4.02	0.0	5.92	6.07
Wollastonite	0.0	−0.60	−3.07	0.0	−4.52	−4.63
Enstatite	0.0	0.0	0.0	0.0	0.0	0.0
Ferrosilite	0.0	−0.68	−3.49	0.0	−5.14	−5.27
Forsterite	0.0	0.0	0.0	0.0	0.0	0.0
Fayalite	2.93	2.95	4.49	3.24	5.96	4.38
Andradite	0.0	0.0	0.0	0.0	0.0	0.0
Hematite	0.0	0.0	0.0	0.0	0.0	0.0
Magnetite	2.13	0.45	1.00	1.65	5.08	0.0
Sphene	0.0	0.0	0.0	0.0	0.0	0.0
Perovskite	0.0	0.0	0.0	0.0	0.0	0.0
Rutile	0.09	0.0	0.09	0.08	0.16	0.0
Apatite	8.45	7.65	12.64	11.46	11.08	14.60
Calcite	73.11	76.22	69.84	68.88	75.62	70.57
Magnesite	6.81	5.29	4.61	7.56	6.42	6.13
Fluorite	0.0	0.0	0.0	0.0	0.0	0.0
Zircon	0.0	0.0	0.0	0.0	0.0	0.0
Baddeleyite	0.0	0.0	0.0	0.0	0.0	0.0
H_2O	0.28	0.45	0.41	0.34	0.32	0.29
Sum	97.24	94.67	95.21	97.55	103.53	95.23

Notes: For sample descriptions, see Table A-1. Alkalic norms were calculated using the method of LeBas (1973).

Ref. No.	**Sample No.**	**Ref. No.**	**Sample No.**
1425	B3 145.5-146.2	1428	B3 390.45-391.75
1426	B3 290.4-291.4	1430	B4 32.6-37.5
1427	B3 357.0-357.75	1433	B4 381.35-382.0

TABLE A-4. Continued.

	SOVITE					
Ref. No.	**1437**	**1439**	**1418**	**1450**	**1451**	**1453**
Quartz	0.0	0.0	0.0	0.0	0.0	0.0
Corundum	0.0	0.0	0.0	0.0	0.25	0.0
Orthoclase	0.0	1.12	0.0	1.00	0.93	0.98
Albite	0.0	0.0	0.0	0.99	1.79	0.31
Leucite	0.0	0.26	0.0	0.0	0.0	0.0
Kalsilite	0.0	0.0	0.0	0.0	0.0	0.0
Nepheline	0.37	0.56	0.0	1.24	0.77	0.43
Carnegieite	0.17	0.0	1.25	0.0	0.0	0.0
Na_2SiO_3	0.86	0.0	0.38	0.0	0.0	0.0
Acmite	0.0	0.22	0.0	1.76	0.0	2.81
Thenardite	0.27	1.20	0.49	0.71	0.97	0.80
Gehlenite	0.0	0.0	0.0	0.0	0.0	0.0
Akermanite	0.0	0.0	0.0	0.0	0.0	0.0
Fe-Aker.	4.11	0.0	5.22	0.0	0.0	0.0
Wollastonite	−3.14	0.0	−3.98	0.0	0.0	0.0
Enstatite	0.0	0.0	0.0	0.0	0.0	0.0
Ferrosilite	−3.57	0.0	−4.53	0.0	0.0	0.0
Forsterite	0.0	0.0	0.0	0.0	0.0	0.0
Fayalite	3.31	2.75	4.57	2.46	2.32	2.50
Andradite	0.0	0.0	0.0	0.0	0.0	0.0
Hematite	0.0	0.0	0.0	0.0	0.0	0.0
Magnetite	0.0	3.99	0.0	2.97	3.63	2.24
Sphene	0.0	0.0	0.0	0.0	0.0	0.0
Perovskite	0.0	0.0	0.0	0.0	0.0	0.0
Rutile	0.0	0.14	0.0	0.05	0.12	0.06
Apatite	2.77	13.61	0.12	12.69	9.33	12.33
Calcite	84.98	64.42	85.47	60.70	69.56	65.51
Magnesite	5.46	8.44	4.90	11.21	6.94	9.52
Fluorite	0.0	0.0	0.0	0.0	0.0	0.0
Zircon	0.0	0.0	0.0	0.0	0.0	0.0
Baddeleyite	0.0	0.0	0.0	0.0	0.0	0.0
H_2O	0.21	0.53	0.33	0.32	0.33	0.22
Sum	95.81	97.23	94.21	96.10	96.96	97.70

Notes: For sample descriptions, see Table A-1. Alkalic norms were calculated using the method of LeBas (1973).

Ref. No.	**Sample No.**	**Ref. No.**	**Sample No.**
1437	B4 558.0-558.8	1450	B6 329.0-329.6
1439	B4 727.0-727.65	1451	B6 530.1-530.8
1418	B2 454.8-455.6	1453	B6 620.1-620.75

TABLE A-4. Continued.

	SOVITE				LAMPRO-PHYRE	FENITE
Ref. No.	**1454**	**1456**	**1458**	**1459**	**1447**	**1415**
Quartz	2.25	0.0	1.14	10.60	0.0	9.66
Corundum	0.0	0.10	0.43	0.0	0.0	0.0
Orthoclase	0.18	0.0	1.06	0.3	21.40	15.35
Albite	1.79	0.0	0.0	2.8	8.79	54.93
Leucite	0.0	0.0	0.0	0.0	0.0	0.0
Kalsilite	0.0	0.0	0.0	0.0	0.0	0.0
Nepheline	0.0	0.0	0.0	0.0	0.05	0.0
Carnegieite	0.0	1.68	0.0	0.0	0.0	0.0
Na_2SiO_3	0.0	0.0	0.0	0.0	0.0	0.0
Acmite	2.07	0.0	0.0	0.0	0.0	0.0
Thenardite	1.24	0.40	1.54	0.04	1.15	0.44
Gehlenite	0.0	0.0	0.0	0.0	1.82	4.03
Akermanite	0.0	0.0	0.0	0.0	0.0	0.0
Fe-Aker.	0.0	4.12	0.0	0.0	0.0	0.0
Wollastonite	0.0	−3.14	0.0	0.0	0.0	0.0
Enstatite	0.0	0.0	0.0	0.0	0.0	0.0
Ferrosilite	0.0	−3.58	0.0	0.0	0.0	0.0
Forsterite	0.0	0.0	0.0	0.0	22.58	5.19
Fayalite	2.86	3.12	2.30	1.25	11.72	3.11
Andradite	0.0	0.0	0.0	0.0	0.0	0.0
Hematite	0.0	0.0	0.0	0.0	0.0	0.0
Magnetite	1.82	0.0	4.69	0.0	5.67	3.12
Sphene	0.0	0.0	0.0	0.0	2.64	0.51
Perovskite	0.0	0.0	0.0	0.0	0.0	0.0
Rutile	0.07	0.0	0.13	0.0	2.58	0.38
Apatite	8.66	1.82	14.82	1.37	1.51	0.38
Calcite	69.33	85.03	62.51	76.56	18.11	2.61
Magnesite	7.99	4.44	7.88	4.42	0.0	0.0
Fluorite	0.0	0.0	0.0	0.0	0.0	0.0
Zircon	0.0	0.0	0.0	0.0	0.0	0.0
Baddeleyite	0.0	0.0	0.0	0.0	0.0	0.0
H_2O	0.39	0.23	0.33	0.12	1.00	0.53
Sum	98.69	94.21	96.81	97.46	99.02	100.24

Notes: For sample descriptions, see Table A-1. Alkalic norms were calculated using the method of LeBas (1973).

Ref. No.	Sample No.	Ref. No.	Sample No.
1454	B6 644.8-645.55	1459	B6 988.15-988.95
1456	B6 793.1-793.8	1447	B5 521.4-522.0
1458	B6 915.2-915.85	1415	B1 78.7-79.2

TABLE A-4. Continued.

	FENITE					
Ref. No.	**1416**	**1417**	**1446**	**1448**	**1419**	**1420**
Quartz	0.0	0.0	15.89	27.40	15.37	0.0
Corundum	0.0	0.0	3.97	4.82	0.13	0.0
Orthoclase	12.00	9.34	10.57	8.26	4.49	16.26
Albite	64.39	67.50	50.51	47.87	33.15	43.74
Leucite	0.0	0.0	0.0	0.0	0.0	0.0
Kalsilite	0.0	0.0	0.0	0.0	0.0	0.0
Nepheline	3.81	2.45	0.0	0.0	0.0	2.79
Carnegieite	0.0	0.0	0.0	0.0	0.0	0.0
Na_2SiO_3	0.0	0.0	0.0	0.0	0.0	0.0
Acmite	0.0	0.0	0.0	0.0	0.0	0.0
Thenardite	0.18	0.22	0.31	0.13	3.37	1.86
Gehlenite	0.38	1.61	6.89	5.77	21.76	1.70
Akermanite	0.0	0.0	0.0	0.0	0.0	0.0
Fe-Aker.	0.0	0.0	0.0	0.0	0.0	0.0
Wollastonite	1.60	2.36	0.0	0.0	0.0	0.24
Enstatite	1.15	1.55	0.0	0.0	0.0	0.15
Ferrosilite	0.30	0.63	0.0	0.0	0.0	0.08
Forsterite	3.99	3.53	2.57	0.97	6.48	11.58
Fayalite	1.17	1.58	3.97	0.95	7.94	6.27
Andradite	0.0	0.0	0.0	0.0	0.0	0.0
Hematite	1.37	1.57	0.0	0.0	0.0	0.0
Magnetite	2.72	1.26	1.41	0.03	3.75	3.89
Sphene	1.15	1.03	0.0	0.0	0.0	2.18
Perovskite	0.0	0.0	0.0	0.0	0.0	0.0
Rutile	0.0	0.0	0.49	0.14	0.93	0.0
Apatite	0.31	0.47	0.54	0.07	0.12	0.90
Calcite	4.41	4.34	2.29	1.64	2.54	7.13
Magnesite	0.0	0.0	0.0	0.0	0.0	0.0
Fluorite	0.0	0.0	0.0	0.0	0.0	0.0
Zircon	0.0	0.0	0.0	0.0	0.0	0.0
Baddeleyite	0.0	0.0	0.0	0.0	0.0	0.0
H_2O	0.67	0.58	0.66	0.47	0.50	0.73
Sum	99.59	100.04	100.07	98.53	100.52	99.51

Notes: For sample descriptions, see Table A-1. Alkalic norms were calculated using the method of LeBas (1973).

Ref. No.	**Sample No.**	**Ref. No.**	**Sample No.**
1416	B1 465.5-465.9	1448	B5 584.65-585.25
1417	B1 675.1-676.2	1419	B2 468.0-468.7
1446	B5 468.45-469.0	1420	B2 601.2-601.7

TABLE A-4. Continued.

	FENITE		SILICOCARBONATITE			
Ref. No.	**1423**	**1442**	**1421**	**1422**	**1424**	**1441**
Quartz	0.0	0.0	0.0	3.12	0.0	0.0
Corundum	0.0	0.0	0.63	0.0	0.0	0.0
Orthoclase	19.79	10.93	0.0	12.81	13.87	0.0
Albite	0.0	0.0	0.0	5.09	0.0	0.0
Leucite	0.91	14.51	28.82	0.0	3.32	0.0
Kalsilite	0.0	0.0	5.16	0.0	0.0	0.0
Nepheline	9.08	4.88	4.78	0.0	7.74	0.0
Carnegieite	0.0	0.0	0.0	0.0	0.0	0.31
Na_2SiO_3	0.0	0.0	0.0	1.47	0.0	0.66
Acmite	10.18	3.79	0.0	9.63	10.37	0.0
Thenardite	0.04	1.59	0.09	0.09	0.18	0.0
Gehlenite	0.0	0.0	0.0	0.0	0.0	0.0
Akermanite	0.0	0.0	0.0	0.0	0.0	0.0
Fe-Aker.	0.0	0.0	0.0	0.0	0.0	6.72
Wollastonite	7.40	0.0	0.0	0.0	12.38	−5.13
Enstatite	4.79	0.0	0.0	0.0	8.21	0.0
Ferrosilite	2.10	0.0	0.0	0.0	3.26	−5.84
Forsterite	16.62	14.17	30.59	11.84	16.31	0.0
Fayalite	8.03	12.06	6.62	5.26	7.14	7.49
Andradite	0.0	0.0	0.0	0.0	0.0	0.0
Hematite	0.0	8.0	0.0	0.0	0.92	0.0
Magnetite	0.57	2.02	2.93	0.0	0.0	0.0
Sphene	1.23	0.0	0.0	0.0	1.20	0.0
Perovskite	0.0	0.0	0.0	0.0	0.0	0.0
Rutile	0.0	0.75	0.14	0.23	0.0	0.0
Apatite	6.56	2.96	6.56	9.35	4.40	4.33
Calcite	11.63	26.49	9.76	39.05	8.95	49.91
Magnesite	0.0	4.66	1.42	1.94	0.0	37.51
Fluorite	0.0	0.0	0.0	0.0	0.0	0.0
Zircon	0.0	0.0	0.0	0.0	0.0	0.0
Baddeleyite	0.0	0.0	0.0	0.0	0.0	0.0
H_2O	0.74	0.88	0.99	0.29	0.84	0.13
Sum	99.65	99.69	98.49	100.17	99.08	96.08

Notes: For sample descriptions, see Table A-1. Alkalic norms were calculated using the method of LeBas (1973).

Ref. No.	Sample No.	Ref. No.	Sample No.
1423	B3 40.9-41.6	1422	B3 17.4-17.9
1442	B5 39.1-39.3	1424	B3 76.2-76.9
1421	B2 677.3-677.8	1441	B5 31.6-32.2

TABLE A-4. Continued.

	SILICOCARBONATITE					
Ref. No.	**1431**	**1432**	**1434**	**1435**	**1436**	**1438**
Quartz	0.15	0.0	1.11	0.0	2.49	4.18
Corundum	0.0	0.0	0.70	0.0	0.0	0.0
Orthoclase	0.65	3.14	2.18	2.36	4.13	16.64
Albite	3.40	0.23	0.0	1.88	0.73	3.23
Leucite	0.0	0.0	0.0	0.0	0.0	0.0
Kalsilite	0.0	0.0	0.0	0.0	0.0	0.0
Nepheline	0.0	0.34	0.0	0.12	0.0	0.0
Carnegieite	0.0	0.0	0.0	0.0	0.0	0.0
Na_2SiO_3	0.0	0.0	0.0	0.0	0.0	2.60
Acmite	1.07	4.63	0.0	4.23	8.62	6.57
Thenardite	0.31	0.80	0.50	0.58	1.55	0.09
Gehlenite	0.0	0.0	0.0	0.0	0.0	0.0
Akermanite	0.0	0.0	0.0	0.0	0.0	0.0
Fe-Aker.	0.0	0.0	0.0	0.0	0.0	0.0
Wollastonite	0.0	0.0	0.0	0.0	0.0	0.0
Enstatite	0.0	0.0	0.0	0.0	0.0	0.0
Ferrosilite	0.0	0.0	0.0	0.0	0.0	0.0
Forsterite	14.61	25.65	17.49	18.69	14.41	19.52
Fayalite	8.69	11.37	6.69	8.50	5.79	9.26
Andradite	0.0	0.0	0.0	0.0	0.0	0.0
Hematite	0.0	0.0	0.0	0.0	0.0	0.0
Magnetite	10.38	32.83	35.01	40.58	41.58	0.0
Sphene	0.0	0.0	0.0	0.0	0.46	0.0
Perovskite	0.0	0.0	0.0	0.0	0.0	0.0
Rutile	0.55	1.89	2.23	2.42	2.56	0.40
Apatite	6.46	0.36	23.91	5.37	0.33	7.98
Calcite	47.08	15.79	6.06	12.68	18.34	27.04
Magnesite	5.30	2.14	2.77	2.58	0.0	0.96
Fluorite	0.0	0.0	0.0	0.0	0.0	0.0
Zircon	0.0	0.0	0.0	0.0	0.0	0.0
Baddeleyite	0.0	0.0	0.0	0.0	0.0	0.0
H_2O	0.85	2.00	1.38	0.99	0.45	0.82
Sum	99.05	101.16	100.03	100.98	101.45	99.17

Notes: For sample descriptions, see Table A-1. Alkalic norms were calculated using the method of LeBas (1973).

Ref. No.	**Sample No.**	**Ref. No.**	**Sample No.**
1431	B4 104.5-104.75	1435	B4 477.35-478.0
1432	B4 110.9-111.6	1436	B4 503.7-504.3
1434	B4 406.3-406.9	1438	B4 673.15-673.7

TABLE A-4. Continued.

	SILICOCARBONATITE					
Ref. No.	**1440**	**1443**	**1444**	**1449**	**1452**	**1457**
Quartz	2.43	0.0	0.0	3.47	2.91	5.10
Corundum	0.0	0.0	0.0	0.0	0.0	0.0
Orthoclase	4.69	0.0	14.32	20.07	11.45	4.14
Albite	0.0	0.0	0.0	0.0	0.0	0.0
Leucite	0.0	27.44	15.50	0.0	0.0	0.0
Kalsilite	0.0	1.85	0.0	0.0	0.0	0.0
Nepheline	0.0	0.73	1.32	0.0	0.0	0.0
Carnegieite	0.0	0.0	0.0	0.0	0.0	0.0
Na_2SiO_3	0.0	0.44	2.63	4.25	0.0	0.0
Acmite	0.0	3.30	8.30	7.98	8.53	14.50
Thenardite	1.01	0.31	0.13	0.13	0.97	0.97
Gehlenite	0.0	0.0	0.0	0.0	0.0	0.0
Akermanite	0.0	0.0	0.0	0.0	0.0	0.0
Fe-Aker.	0.0	0.0	0.0	0.0	0.0	0.0
Wollastonite	0.0	0.0	0.0	0.0	0.0	0.0
Enstatite	0.0	0.0	0.0	0.0	0.0	0.0
Ferrosilite	0.0	0.0	0.0	0.0	0.0	0.0
Forsterite	17.78	20.49	26.89	17.52	23.80	12.40
Fayalite	8.48	8.62	8.05	6.58	3.77	6.04
Andradite	0.0	0.0	0.0	0.0	0.0	0.0
Hematite	0.0	0.0	0.0	0.0	0.0	0.0
Magnetite	10.31	0.0	0.0	0.0	9.65	1.39
Sphene	0.0	0.0	0.0	0.0	0.0	0.0
Perovskite	0.0	0.0	0.0	0.0	0.0	0.0
Rutile	0.58	0.49	0.39	0.20	1.12	0.29
Apatite	9.18	4.69	5.30	7.17	2.53	0.24
Calcite	39.03	23.70	14.18	26.76	26.20	47.38
Magnesite	5.96	6.05	1.49	4.81	6.24	6.58
Fluorite	0.0	0.0	0.0	0.0	0.0	0.0
Zircon	0.0	0.0	0.0	0.0	0.0	0.0
Baddeleyite	0.0	0.0	0.0	0.0	0.0	0.0
H_2O	1.22	0.58	0.96	0.47	2.09	0.34
Sum	100.67	98.69	99.46	99.43	99.26	98.91

Notes: For sample descriptions, see Table A-1. Alkalic norms were calculated using the method of LeBas (1973).

Ref. No.	Sample No.	Ref. No.	Sample No.
1440	B4 800.0-800.6	1449	B6 30.1-30.7
1443	B5 135.6-136.4	1452	B6 554.2-555.0
1444	B5 145.5-146.1	1457	B6 892.0-892.65

Appendix B

Petrographic Descriptions, Chemical Analyses and Normative Compositions of Samples from the Borden Township Carbonatite Complex. (Samples 1549–1567, collected 1983).

TABLE B-1. PETROGRAPHIC DESCRIPTIONS OF WHOLE-ROCK SAMPLES FROM OUTCROP, COLLECTED IN 1983 FROM THE BORDEN TOWNSHIP CARBONATITE COMPLEX. REFERENCE NUMBERS ARE PLOTTED ON FIGURE 3 (CHART A).

Reference No. 1549
Sample No. B011-1A
Sovite

Field Description. Fine to medium grained magnetite-bearing sovite. Trace pyrrhotite, 2-3 percent phlogopite. The rock is light grey in colour and relatively equigranular. Rock is not banded or foliated.

Petrographic Description. Fine to medium grained, equigranular, massive, with lobate grain boundaries. Apatite forms rounded to rounded-elongate subhedral grains. Amphibole occurs as acicular subhedral to euhedral crystals. Very minor reddish brown biotite with irregular turbid rims. Totally altered elliptical grains may be former olivine grains. Fine grained disseminated magnetite may be present in core of these altered grains. Carbonate forms a mosaic of anhedral interlocking grains. Biotite-bearing amphibole - apatite sovite.

Reference No. 1550
Sample No. B011-1B
Lamprophyre dike

Field Description. Medium grained, equigranular, massive, biotite lamprophyre dike. No foliation.

Petrographic Description. Fine to medium grained, inequigranular, porphyritic-seriate, hypidiomorphic, with straight to serrate grain boundaries. Biotite is present as anhedral ragged grains. Some biotite grains contain inclusions of disseminated magnetite. Magnetite is present as small disseminated anhedral grains. Amphibole forms tiny acicular crystals. Clinopyroxene occurs as subhedral phenocrysts that are relatively fresh. Pyroxene lamprophyre.

Reference No. 1551
Sample No. B011-1C
Sovite

Field Description. Medium grained, equigranular, massive, light grey sovite. Minor magnetite, pyrrhotite, and amphibole.

Petrographic Description. Fine grained, equigranular, massive, hypidiomorphic, with curved to lobate grain boundaries. Apatite is present as rounded to rounded-elongate subhedral grains. Minor anhedral biotite occurs as reddish brown grains with cuspate turbid margins. There are traces of opaques and traces of clinopyroxene with turbid alteration along rims of grains. Carbonate forms a mosaic of anhedral interlocking grains. Biotite-bearing apatite sovite.

Reference No. 1552
Sample No. B011-2
Sovite

Field Description. Medium to coarse grained magnetite sovite. Rock contains up to 10 percent magnetite. Traces to minor amounts of pyrrhotite and phlogopite.

Petrographic Description. Fine to medium grained, massive, hypidiomorphic, with curved to lobate grain boundaries. Traces of olivine are present with some alteration to biotite. Some totally altered grains may also be former olivine. Apatite forms rounded to rounded-elongate subhedral grains. Biotite is present as anhedral grains some of which have turbid rims. Amphibole forms acicular grains some of which occur in radiating clusters. Traces of opaques are present. Carbonate forms a mosaic of anhedral interlocking grains. Amphibole-, biotite-bearing apatite sovite.

Reference No. 1553
Sample No. B011-3A
Fenite

Field Description. Medium grained, equigranular silicocarbonatite. Rock contains approximately 70 percent biotite. Carbonate locally clotty.

Petrographic Description. Fine grained, massive, allotriomorphic, with angular to curved grain boundaries. Biotite forms anhedral interlocking grains. The (001) cleavage is commonly bent. Amphibole is present as green pleochroic acicular grains. Traces of apatite and clinopyroxene are present. Plagioclase feldspar of albitic composition is common. Feldspar has well developed protoclastic texture. Feldspar - amphibole - biotite silicocarbonatite (fenite).

Reference No. 1554
Sample No. B011-3B
Sovite

Field Description. Fine to medium grained, light brown, massive sovite.

Petrographic Description. Fine grained, equigranular, massive, allotriomorphic, with curved to lobate grain boundaries. Rock is weakly banded. Apatite forms anhedral, rounded to rounded-elongate subhedral grains. Carbonate occurs as an interlocking mosaic of anhedral grains. Apatite sovite.

Reference No. 1555
Sample No. B011-3C
Sovite

Field Description. Medium to coarse grained, inequigranular, apatite, phlogopite sovite. Minor magnetite. Rock is estimated to contain 10 percent apatite, 15 to 20 percent phlogopite.

Petrographic Description. Fine to coarse grained, inequigranular-seriate, with curved to lobate grain boundaries. Clinopyroxene forms subhedral to euhedral turbid grains with inclusions of apatite and carbonate. Disseminated subhedral to euhedral opaques are present. Apatite forms rounded to rounded-elongate grains which are anhedral to subhedral in form. Biotite occurs as large grains that display bent (001) cleavage. Traces of acicular amphibole are present. Carbonate forms a mosaic of anhedral interlocking grains. Pyroxene - apatite - biotite sovite.

Reference No. 1556
Sample No. B011-3D
Sovite

Field Description. Medium grained, inequigranular-seriate amphibole sovite. Amphibole occurs as long green needle-like crystals up to 2 cm in length. Rock composition is heterogeneous with amphibole occurring as clots. Minor pyrrhotite.

Petrographic Description. Fine grained, equigranular, massive, hypidiomorphic, with curved to lobate grain boundaries. Minor euhedral acicular amphibole is present. Apatite forms rounded to rounded-elongate grains of subhedral form. Carbonate forms a mosaic of interlocking anhedral grains. Traces of sphene are present. Amphibole-bearing apatite sovite.

Reference No. 1557
Sample No. B011-6A
Sovite

Field Description. Medium grained, inequigranular sovite with green acicular amphibole crystals up to 8 mm in length. Amphibole forms up to 15 percent of the rock.

Petrographic Description. Fine grained, equigranular, hypidiomorphic, with curved to lobate grain boundaries. Amphibole occurs as euhedral, twinned acicular crystals. Carbonate forms an interlocking mosaic of anhedral grains. Amphibole sovite.

Reference No. 1558
Sample No. B011-6B
Sovite

Field Description. Medium grained, equigranular, massive, light brown, amphibole sovite. Amphibole occurs as stubby crystals up to 3 mm in length. Minor phlogopite.

Petrographic Description. Fine grained, equigranular, massive, hypidiomorphic, with curved to lobate grain boundaries. Apatite forms rounded to rounded-elongate anhedral grains. Carbonate forms an interlocking mosaic of anhedral grains. Apatite sovite.

Reference No. 1559
Sample No. B011-6C
Fenite

Field Description. Medium grained, inequigranular-seriate silicocarbonatite. Rock is composed of approximately 70 percent amphibole, 15 percent biotite and the remainder is pink carbonate.

Petrographic Description. Fine to medium grained, inequigranular-seriate, hypidiomorphic, with curved to serrate grain boundaries. Clinopyroxene forms ragged grains with apatite plus carbonate inclusions. Clinopyroxene is altering to green acicular amphibole. Apatite forms rounded to rounded-elongate subhedral grains. Amphibole is present as subhedral interlocking green prismatic grains. Locally the amphibole is after clinopyroxene and it may contain inclusions of pyroxene. Minor interstitial anhedral carbonate is present. Plagioclase feldspar of albitic composition forms large amoeboid poikiloblastic grains with abundant apatite and pyroxene inclusions. Albite twin planes are bent. Apatite - amphibole - pyroxene silicocarbonatite (fenite).

Reference No. 1560
Sample No. B011-6D
Sovite

Field Description. Fine to medium grained, equigranular, light brown sovite.

Petrographic Description. Fine grained, equigranular, massive, hypidiomorphic, with curved to lobate grain boundaries. Apatite is present as rounded to rounded-elongate anhedral grains. Magnetite occurs as anhedral grains with carbonate inclusions. Carbonate forms an interlocking mosaic of anhedral grains. Magnetite - apatite sovite.

Reference No. 1561
Sample No. B011-7A
Sovite

Field Description Fine to coarse grained, inequigranular-porphyritic-seriate phlogopite sovite. Up to 10 percent biotite phenocrysts up to 1 cm in diameter occur in a matrix of finer grained biotite-phlogopite and carbonate.

Petrographic Description. Fine grained, massive, equigranular, hypidiomorphic, with curved to lobate grain boundaries. Biotite is present as anhedral grains with tiny carbonate and apatite inclusions. Cores of grains may be darker reddish brown than rims. Apatite forms rounded to rounded-elongate anhedral grains. Carbonate forms an interlocking mosaic of anhedral grains. Biotite - apatite sovite.

Reference No. 1562
Sample No. B011-7B
Sovite

Field Description. Fine grained, equigranular, light brown sovite. No visible foliation.

Petrographic Description. Fine grained, inequigranular-seriate, allotriomorphic, cataclastic, with straight to curved grain boundaries. Carbonate forms an interlocking mosaic of crushed grains. Apatite is present as rounded to rounded-elongate subhedral grains. Apatite sovite.

Reference No. 1563
Sample No. B011-7C
Silicocarbonatite

Field Description. Medium grained, equigranular, banded silicocarbonatite. Sample contains 60 to 70 percent biotite. Banding due to variations in biotite-carbonate content.

Petrographic Description. Fine to medium grained, equigranular, hypidiomorphic, with curved to lobate grain boundaries. Amphibole forms green prismatic crystals with abundant carbonate inclusions. Biotite forms anhedral to subhedral reddish brown grains which may contain some tiny carbonate inclusions. Apatite forms rounded to rounded-elongate grains that are subhedral to anhedral in form. Carbonate occurs as an interlocking mosaic of anhedral grains. Apatite - amphibole - biotite silicocarbonatite.

Reference No. 1564
Sample No. B011-9
Sovite

Field Description. Fine to medium grained, biotite sovite. Biotite is present in crystals up to 1 mm and occurs in bands. Biotite forms up to 10 percent of the rock.

Petrographic Description. Fine to medium grained, equigranular, allotriomorphic, with curved grain boundaries. Apatite is present as rounded to rounded-elongate anhedral to subhedral grains. Phlogopite forms anhedral irregular grains with rare apatite inclusions. Carbonate forms an interlocking mosaic of anhedral grains. Phlogopite-, apatite-bearing sovite.

Reference No. 1565
Sample No. B011-9A
Sovite

Field Description. Fine to medium grained, equigranular, amphibole-bearing light brown sovite. No foliation visible.

Petrographic Description. Fine grained, equigranular, massive, allotriomorphic, with curved to lobate grain boundaries. Carbonate forms a mosaic of anhedral grains. Sovite.

Reference No. 1566
Sample No. B011-9B
Sovite

Field Description. Fine to medium grained, amphibole sovite. Amphibole occurs in needle-like green crystals and is clotty.

Petrographic Description. Fine grained, equigranular, massive, hypidiomorphic, with curved to straight grain boundaries. Amphibole is present as acicular euhedral crystals commonly associated with apatite. Apatite occurs as rounded to rounded-elongate anhedral grains. Minor biotite occurs as anhedral reddish brown grains. Amphibole and apatite occur together in clots. Biotite - apatite - amphibole sovite.

Reference No. 1567
Sample No. B011-14
Sovite

Field Description. Medium grained, equigranular, grey amphibole sovite. Needle-like green amphibole crystals up to 8 mm in length.

Petrographic Description. Fine to medium grained, equigranular, massive, allotriomorphic, with straight to lobate grain boundaries. Microcline occurs as ragged anhedral perthite grains. Carbonate forms an interlocking mosaic of anhedral grains. Microcline sovite.

TABLE B-2. MAJOR ELEMENT ANALYSES OF WHOLE-ROCK SAMPLES FROM OUTCROP, COLLECTED IN 1983 FROM THE BORDEN TOWNSHIP CARBONATITE COMPLEX. REFERENCE NUMBERS ARE PLOTTED ON FIGURE 3 (CHART A).

	SOVITE						
Ref. No.	**1549**	**1551**	**1552**	**1554**	**1555**	**1556**	**1557**
SiO_2	1.55	0.33	2.25	0.22	12.50	1.82	0.89
Al_2O_3	0.22	0.08	0.09	0.09	1.94	0.29	0.19
Fe_2O_3	1.17	1.07	1.73	0.58	2.05	0.15	00.00
FeO	2.47	0.95	2.47	3.49	4.36	1.24	0.87
MgO	4.02	1.91	5.33	17.70	3.68	2.38	1.95
CaO	45.10	53.30	43.20	28.80	34.60	49.10	53.30
Na_2O	0.73	0.42	0.42	0.11	0.78	0.84	0.71
K_2O	0.05	0.02	0.04	0.03	1.73	0.12	0.05
TiO_2	0.03	0.02	0.04	00.00	0.37	0.01	0.01
P_2O_5	3.40	0.79	4.44	1.58	2.45	1.68	0.01
MnO	0.21	0.14	0.23	0.51	0.21	0.23	0.17
CO_2	38.30	40.10	36.50	44.10	32.50	40.60	41.10
S	0.15	0.11	0.04	00.00	0.19	0.22	00.00
H_2O^+	0.49	0.34	0.48	0.17	0.89	0.19	0.29
H_2O^-	0.06	0.04	0.04	0.05	0.06	0.04	0.04
LOI	36.70	40.70	33.60	42.40	29.30	37.00	41.30
Total	98.00	99.60	97.30	97.40	98.30	98.90	99.60

	SOVITE					
Ref. No.	**1558**	**1561**	**1562**	**1564**	**1565**	**1566**
SiO_2	0.87	2.63	00.00	0.47	0.02	0.82
Al_2O_3	0.39	1.08	0.08	0.17	0.09	0.17
Fe_2O_3	00.00	00.00	0.20	00.00	00.00	0.04
FeO	1.02	1.75	2.76	1.02	0.95	1.02
MgO	2.32	2.62	17.30	2.37	1.85	2.49
CaO	51.30	46.80	29.70	52.60	54.10	52.20
Na_2O	0.48	0.58	0.35	0.56	0.42	0.66
K_2O	0.13	0.85	00.00	0.05	0.06	0.05
TiO_2	0.01	0.03	0.02	00.00	00.00	0.01
P_2O_5	2.56	1.53	6.36	0.23	0.45	0.83
MnO	0.18	0.16	0.29	0.20	0.16	0.16
CO_2	40.30	40.30	41.60	42.60	42.80	40.80
S	0.04	00.00	00.00	00.00	00.00	0.17
H_2O^+	0.30	0.58	0.08	0.16	0.04	0.17
H_2O^-	0.03	0.04	0.04	0.04	0.05	0.03
LOI	39.60	37.80	38.50	42.10	42.30	40.10
Total	99.90	98.90	98.80	100.40	100.10	99.60

Notes: For sample descriptions, see Table B-1. Analyses by Geoscience Laboratories, Ontario Geological Survey, Toronto.

Ref. No.	**Sample No.**	**Ref. No.**	**Sample No.**
1549	B011-1A	1558	B011-6B
1551	B011-1C	1561	B011-7A
1552	B011-2	1562	B011-7B
1554	B011-3B	1564	B011-9
1555	B011-3C	1565	B011-9A
1556	B011-3D	1566	B011-9B
1557	B011-6A		

TABLE B-2. CONTINUED.

	SOVITE		LAMPROPHYRE DIKE	FENITE		SILICOCARBONATITE
Ref. No.	**1567**	**1560**	**1550**	**1553**	**1559**	**1563**
SiO_2	3.14	0.08	36.40	30.80	49.90	24.60
Al_2O_3	1.09	0.08	6.25	5.62	8.62	4.09
Fe_2O_3	0.14	0.99	6.28	4.33	4.12	3.38
FeO	0.44	3.13	8.44	6.18	2.33	5.53
MgO	0.86	18.20	19.20	8.37	6.55	8.46
CaO	50.20	29.50	11.60	18.80	12.60	24.50
Na_2O	1.17	0.28	0.59	2.99	7.08	2.17
K_2O	0.50	00.00	1.56	3.61	0.71	3.32
TiO_2	0.02	0.03	3.49	0.67	0.16	0.47
P_2O_5	00.00	3.04	0.47	1.82	1.08	1.93
MnO	0.20	0.30	0.23	0.25	0.21	0.16
CO_2	41.60	42.90	1.45	14.10	4.80	19.50
S	00.00	00.00	0.18	0.04	00.00	00.00
H_2O^+	0.10	0.27	2.06	1.42	0.70	1.17
H_2O^-	0.04	0.05	0.06	0.08	0.05	0.06
LOI	38.90	40.80	2.50	13.60	4.40	18.60
Total	99.50	98.90	98.30	99.10	98.90	99.30

Notes: For sample descriptions, see Table B-1. Analyses by Geoscience Laboratories, Ontario Geological Survey, Toronto.

Ref. No.	Sample No.	Ref. No.	Sample No.
1567	B011-14	1553	B011-3A
1560	B011-6D	1559	B011-6C
1550	B011-1B	1563	B011-7C

TABLE B-3. TRACE ELEMENT ANALYSES OF WHOLE-ROCK SAMPLES FROM OUTCROP, COLLECTED IN 1983 FROM THE BORDEN TOWNSHIP CARBONATITE COMPLEX. REFERENCE NUMBERS ARE PLOTTED ON FIGURE 3 (CHART A).

	SOVITE						
Ref. No.	**1549**	**1551**	**1552**	**1554**	**1555**	**1556**	**1557**
Ag	<2	<2	<2	<2	<2	<2	<2
Ba	290	340	320	150	370	400	460
Be	<1	<1	<1	<1	1	<1	<1
Co	7	6	8	5	5	<5	<5
Cr	<5	<5	<5	<5	<5	<5	<5
Cu	5	5	5	5	7	10	12
Ga	2	<1	<1	<1	12	1	<1
Li	<3	<3	4	<3	4	<3	<3
Mo	<10	<10	<10	<10	<10	<10	<10
Nb	<1	2	<1	145	50	9	5
Ni	<5	<5	<5	<5	<5	<5	<5
Pb	25	<10	16	26	10	<10	10
Rb	10	<10	10	<10	50	<10	10
Sc	6	<1	<1	9	2	4	3
Sn	2	2	3	2	5	3	<1
Sr	2770	2825	2985	2785	2730	3515	3955
V	17	14	17	11	85	10	8
Y	80	15	19	17	35	20	25
Zn	35	22	49	38	84	25	16
Zr	3	<1	<1	7	45	4	2
La	135	40	55	65	90	60	45
Nd	145	<30	45	145	85	145	125
Ce	350	<35	50	265	260	195	265

Notes: For sample descriptions, see Table B-1. Analyses by Geoscience Laboratories, Ontario Geological Survey, Toronto.

Ref. No.	Sample No.	Ref. No.	Sample No.
1549	B011-1A	1555	B011-3C
1551	B011-1C	1556	B011-3D
1552	B011-2	1557	B011-6A
1554	B011-3B		

TABLE B-3. CONTINUED.

	SOVITE					
Ref. No.	**1558**	**1561**	**1562**	**1564**	**1565**	**1566**
Ag	<2	<2	<2	<2	<2	<2
Ba	410	490	100	390	580	370
Be	<1	<1	<1	<1	<1	<1
Co	<5	<5	<5	<5	<5	5
Cr	<5	<5	<5	<5	<5	<5
Cu	5	<5	<5	6	6	16
Ga	2	4	<1	<1	<1	<1
Li	<3	<3	3	<3	<3	<3
Mo	<10	<10	<10	<10	<10	<10
Nb	4	9	5	<1	<1	<1
Ni	<5	<5	<5	<5	<5	<5
Pb	32	13	<10	63	10	14
Rb	10	30	10	10	10	10
Sc	3	1	1	5	1	2
Sn	<1	2	<1	3	1	1
Sr	3480	3420	2115	3600	3925	3140
V	4	10	5	3	<1	2
Y	25	25	6	85	21	16
Zn	16	34	24	16	13	16
Zr	45	<1	<1	<1	<1	<1
La	75	60	35	145	45	30
Nd	145	95	50	195	90	65
Ce	155	125	<35	410	155	<35

Notes: For sample descriptions, see Table B-1. Analyses by Geoscience Laboratories, Ontario Geological Survey, Toronto.

Ref. No.	**Sample No.**	**Ref. No.**	**Sample No.**
1558	B011-6B	1564	B011-9
1561	B011-7A	1565	B011-9A
1562	B011-7B	1566	B011-9B

TABLE B-3. CONTINUED.

	SOVITE		LAMPROPHYRE DIKE	FENITE		SILICOCARBONATITE
Ref. No.	**1567**	**1560**	**1550**	**1553**	**1559**	**1563**
Ag	<2	<2	<2	<2	<2	<2
Ba	520	120	660	510	320	420
Be	1	<1	2	3	5	3
Co	<5	<5	79	13	6	12
Cr	<5	<5	975	29	10	60
Cu	14	<5	94	6	<5	5
Ga	3	<1	8	6	11	5
Li	3	<3	6	12	4	6
Mo	<10	<10	<10	<10	<10	<10
Nb	23	9	75	90	70	70
Ni	<5	<5	660	5	<5	16
Pb	15	<10	<10	<10	55	<10
Rb	20	10	50	100	20	80
Sc	<1	5	4	8	7	5
Sn	2	2	7	5	12	8
Sr	4210	2305	465	1505	630	1745
V	2	17	205	125	75	140
Y	45	9	7	30	16	40
Zn	33	33	119	160	78	129
Zr	3	<1	170	110	450	100
La	110	45	80	105	50	110
Nd	160	70	45	75	50	90
Ce	<35	70	80	200	125	240

Notes: For sample descriptions, see Table B-1. Analyses by Geoscience Laboratories, Ontario Geological Survey, Toronto.

Ref. No.	Sample No.	Ref. No.	Sample No.
1567	B011-14	1553	B011-3A
1560	B011-6D	1559	B011-6C
1550	B011-1B	1563	B011-7C

TABLE B-4. NORMATIVE MINERALS (ALKALIC ROCKS) FOR WHOLE-ROCK SAMPLES COLLECTED IN 1983 FROM THE BORDEN TOWNSHIP CARBONATITE COMPLEX.

	SOVITE						
Ref. No.	**1549**	**1551**	**1552**	**1554**	**1555**	**1556**	**1557**
Quartz					2.49		
Corundum							
Orthoclase					10.21	0.54	
Albite					0.35	0.33	
Leucite							
Kalsilite		0.01	0.09	0.04			0.03
Nepheline	0.62	0.22	0.18	0.22		0.36	0.52
Carnegieite	0.01						
Na_2SiO_3						0.51	1.23
Acmite	2.53	1.28	2.34	0.56	2.77	0.43	
Thenardite	0.66	0.49	0.18		0.84	0.97	
Gehlenite							
Akermanite		10.13					8.55
Fe-Aker.		3.62	0.11	6.00			2.86
Wollastonite							
Enstatite							
Ferrosilite	3.19						
Forsterite		4.68					4.48
Fayalite	4.85	2.18	3.29	7.45	5.79	2.09	1.96
Andradite							
Hematite		0.63					
Magnetite	0.43		1.34	0.56	1.59		
Sphene							
Perovskite		0.03					0.02
Rutile	0.03		0.04		0.37	0.01	
Apatite	8.05	1.87	10.51	3.74	5.80	3.98	0.02
Calcite	72.68	91.12	66.92	47.93	56.23	83.98	93.39
Magnesite	8.38		11.11	36.88	7.67	4.96	
Fluorite							
Zircon							
Baddeleyite							
H_2O	0.55	0.38	0.52	0.22	0.95	0.23	0.33
Sum	96.47	99.93	96.43	93.82	95.06	98.39	99.75

Notes: For sample descriptions, see Table B-1. Alkalic norms were calculated using the method of LeBas (1973).

Ref. No.	**Sample No.**	**Ref. No.**	**Sample No.**
1549	B011-1A	1555	B011-3C
1551	B011-1C	1556	B011-3D
1552	B011-2	1557	B011-6A
1554	B011-3B		

TABLE B-4. CONTINUED.

	SOVITE					
Ref. No.	**1558**	**1561**	**1562**	**1564**	**1565**	**1566**
Quartz						
Corundum						
Orthoclase						
Albite						
Leucite		0.32				
Kalsilite	0.18	2.45		0.05	0.18	0.05
Nepheline	0.95	0.61		0.44	0.10	0.44
Carnegieite			0.22			
Na_2SiO_3	0.49	0.95	0.44	0.96	0.80	0.48
Acmite			0.58			0.12
Thenardite	0.18					0.75
Gehlenite						
Akermanite	0.01			2.85	3.86	3.76
Fe-Aker.	1.14		6.37	1.99	2.10	1.40
Wollastonite						
Enstatite						
Ferrosilite						
Forsterite	0.01			2.63	3.21	4.42
Fayalite	2.09	2.71	6.47	2.40	2.28	2.15
Andradite						
Hematite						
Magnetite						
Sphene						
Perovskite						
Rutile	0.01	0.03	0.02			0.01
Apatite	6.06	3.62	15.05	0.54	1.07	1.96
Calcite	85.83	80.22	38.24	93.63	95.83	91.46
Magnesite	4.82	5.46	36.05	2.66	1.19	1.05
Fluorite						
Zircon						
Baddeleyite						
H_2O	0.33	0.62	0.12	0.20	0.09	0.20
Sum	100.23	97.01	93.17	100.60	101.17	100.02

Notes: For sample descriptions, see Table B-1. Alkalic norms were calculated using the method of LeBas (1973).

Ref. No.	**Sample No.**	**Ref. No.**	**Sample No.**
1558	B011-6B	1564	B011-9
1561	B011-7A	1565	B011-9A
1562	B011-7B	1566	B011-9B

TABLE B-4. CONTINUED.

	SOVITE		LAMPROPHYRE DIKE	FENITE		SILICOCARBONATITE
Ref. No.	**1567**	**1560**	**1550**	**1553**	**1559**	**1563**
Quartz			3.70			
Corundum						
Orthoclase	0.90		9.21	19.04	3.27	13.47
Albite			2.05	2.38	37.76	
Leucite	0.82					4.10
Kalsilite						
Nepheline	2.10			4.77	1.93	1.90
Carnegieite		0.22				
Na_2SiO_3	1.54			0.38	1.39	1.10
Acmite	0.41	1.72		12.53	11.92	9.78
Thenardite			0.80	0.18		
Gehlenite			11.19			
Akermanite						
Fe-Aker.		7.67				
Wollastonite			4.47		10.33	
Enstatite			3.29		7.31	
Ferrosilite			0.74		2.10	
Forsterite			31.04	12.71	6.26	11.22
Fayalite	0.91	7.20	7.73	9.13	1.99	8.08
Andradite						
Hematite						
Magnetite		0.57	9.12			
Sphene			8.56		0.39	
Perovskite						
Rutile	0.02	0.03		0.67		0.47
Apatite		7.20	1.11	4.31	2.56	4.57
Calcite	89.96	45.69	3.29	29.43	10.91	39.35
Magnesite	1.79	37.93		2.19		4.17
Fluorite						
Zircon			0.03	0.01	0.07	0.01
Baddeleyite						
H_2O	0.14	0.32	2.12	1.50	0.75	1.23
Sum	98.59	96.04	98.45	99.23	98.94	99.43

Notes: For sample descriptions, see Table B-1. Alkalic norms were calculated using the method of LeBas (1973).

Ref. No.	Sample No.	Ref. No.	Sample No.
1567	B011-14	1553	B011-3A
1560	B011-6D	1559	B011-6C
1550	B011-1B	1563	B011-7C

Appendix C

Average Chemical Compositions of Lithologic Units for the Borden Township Carbonatite Complex.

TABLE C-1. AVERAGE CHEMICAL COMPOSITIONS.

	SOVITE (N = 32)		LAMPROPHYRE DIKE (N = 2)	
	MEAN	STANDARD DEVIATION	MEAN	STANDARD DEVIATION
SiO_2	2.11	3.12	35.35	1.48
Al_2O_3	0.46	0.40	6.29	0.06
Fe_2O_3	1.02	1.12	5.09	1.68
FeO	2.08	1.03	9.08	0.91
MgO	4.84	5.08	16.10	4.38
CaO	44.65	7.08	12.05	0.64
Na_2O	0.63	0.22	1.07	0.68
K_2O	0.20	0.34	2.60	1.46
TiO_2	0.05	0.07	3.57	0.11
P_2O_5	2.87	2.11	0.56	0.12
MnO	0.20	0.08	0.25	0.04
CO_2	39.76	3.55	4.71	4.61
S	0.13	0.13	0.22	0.06
H_2O^+	0.19	0.21	1.39	0.94
H_2O^-	0.14	0.12	0.17	0.15
LOI	36.87	4.03	6.15	5.16
Total	98.33	2.08	98.52	0.31
Ag	0	0	0	0
Ba	300	115	635	35
Co	6	6	69	14
Cr	5	6	838	194
Cu	8	4	121	38
Li	1	2	15	13
Ni	0	0	540	170
Pb	15	11	6	8
Rb	4	6	230	0
Zn	31	16	118	2
Mo	0	0	0	0
Be	<1	<1	2	0
Ga	2	3	8	0
Mo	0	0	0	0
Nb	8	27	78	4
Sc	3	4	12	11
Sn	2	1	7	0
Sr	4118	1267	633	237
V	27	34	303	138
Y	63	38	19	16
Zr	39	110	185	21
Ce	153	135	80	0
La	125	77	40	57
Nd	104	53	45	0
Ce	199	36	100	0
Rb	13	13	50	0
Nd	109	21	60	0
Yb	5	2	1	0

Notes: (a) Elements which are listed more than once have been analysed by different methods. (b) Statistics were calculated in 1987 using all samples.

TABLE C-1. Continued.

	FENITE (N = 11)		SILICOCARBONATITE (N = 16)	
	MEAN	STANDARD DEVIATION	MEAN	STANDARD DEVIATION
SiO_2	50.65	12.77	25.12	9.26
Al_2O_3	12.78	4.76	3.35	2.99
Fe_2O_3	2.65	1.30	10.10	10.64
FeO	4.23	2.63	8.63	5.13
MgO	5.25	3.68	12.53	3.14
CaO	8.93	5.75	17.89	7.22
Na_2O	5.64	2.18	1.70	0.97
K_2O	2.51	1.46	2.65	2.45
TiO_2	0.55	0.26	0.91	0.89
P_2O_5	0.74	0.90	2.03	1.26
MnO	0.15	0.09	0.28	0.12
CO_2	4.46	4.99	12.76	6.88
S	0.17	0.24	0.12	0.12
H_2O^+	0.46	0.40	0.75	0.49
H_2O^-	0.27	0.16	0.22	0.10
LOI	4.56	4.51	12.35	6.40
Total	99.44	0.53	99.03	2.45
Ag	0	0	0	0
Ba	856	377	554	283
Co	23	19	32	20
Cr	112	103	112	274
Cu	64	82	15	18
Li	9	3	5	3
Ni	54	61	45	149
Pb	14	15	2	4
Rb	60	32	57	47
Zn	110	45	184	108
Mo	0	0	1	2
Ag	1	1		
Be	3	2	3	0
Ga	17	9	5	0
Mo	0	0	0	0
Nb	51	66	83	74
Sc	14	16	16	13
Sn	5	5	8	0
Sr	732	451	1509	908
V	110	107	261	335
Y	16	17	41	16
Zr	271	303	978	1673
Ce	163	53	240	0
La	17	37	7	28
Nd	63	18	90	0
Ce	73	42	125	49
Rb	60	57	80	0
Ce	80	0		
Nd	37	18	67	28
Yb	1	1	3	2

Notes: (a) Elements which are listed more than once have been analysed by different methods. (b) Statistics were calculated in 1987 using all samples.

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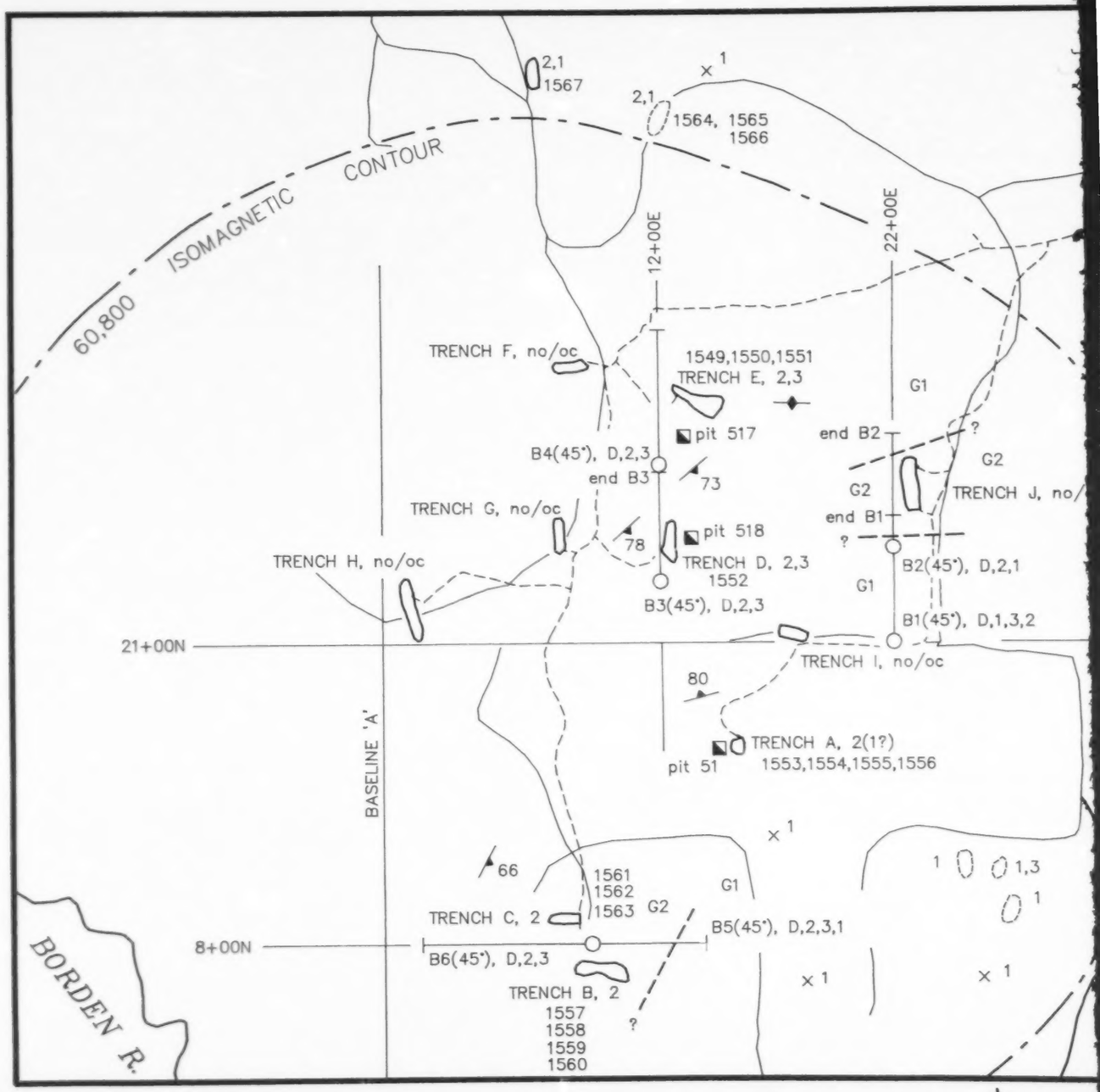

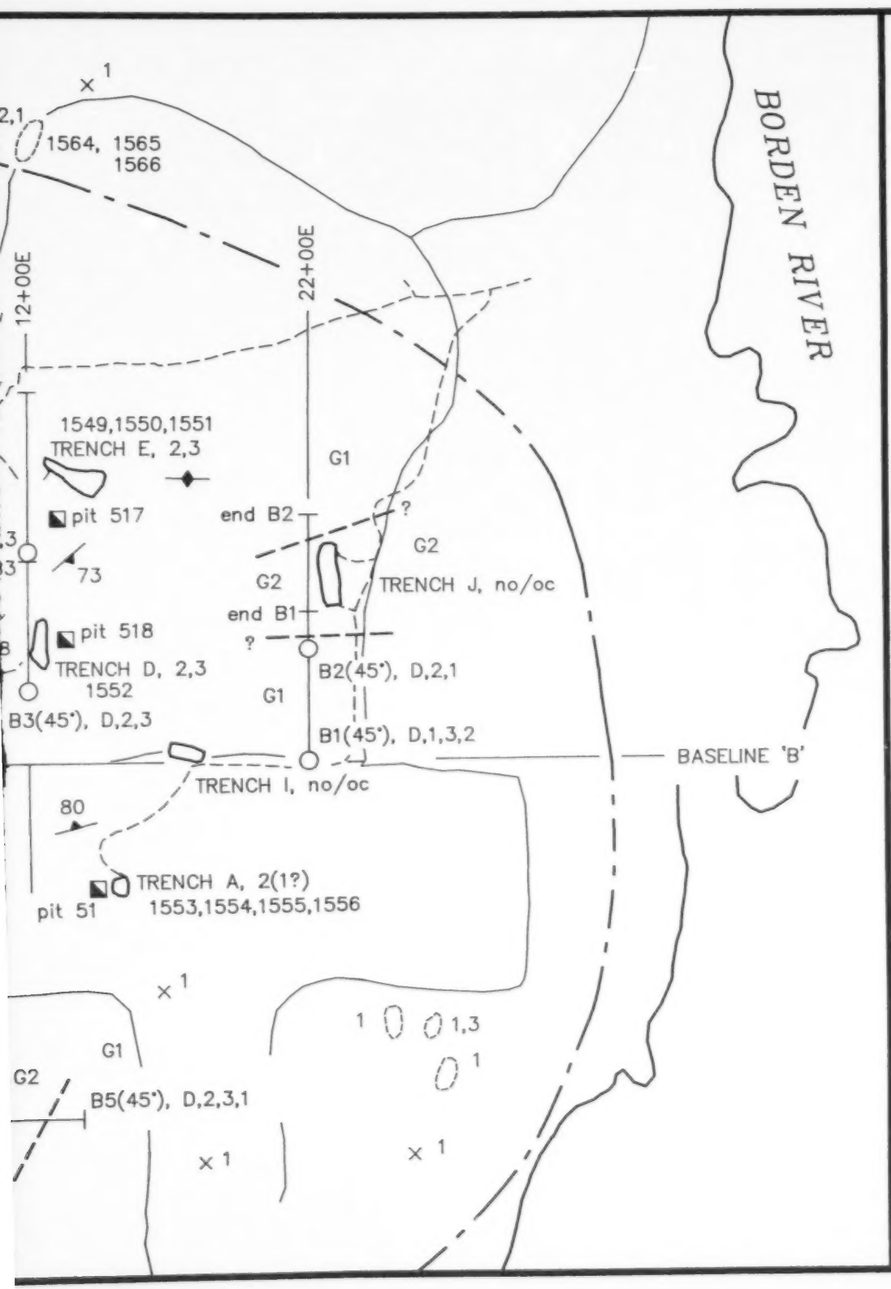

Chart A — Borden Township Carbonatite Complex

Figure 3. Geological map of trenches on the Borden Township Carbonatite Complex, showing locations of diamond drill holes. Modified after McCarthy and Brewster (1978).

B2	Diamond Drill Hole
D	Lithologic data from diamond drilling.
	Skid trail (1977)
no/oc	No outcrop
	Geophysically inferred contact
3	Lamprophyre dike
2	Carbonatite (unsubdivided)
1	Fenite (syenitic)
G	Geophysical interpretation
	Gneissosity; (inclined, vertical)
60,800	Isomagnetic contour
	Logging road (1979)
	Area of bedrock outcrop.
×	Small bedrock outcrop.
1566	Location of sample for whole–rock analysis (see report appendix).

Scale in Metres

0 — 500